ABSTRACT

Title of Thesis: ASSESSMENT OF PESTICIDE RESIDUES IN FARMERS' HOUSE DUST AND EDUCATIONAL INTERVENTION TO IMPROVE PESTICIDE HANDLING PRACTICES.

Lisa Marie Clark, Master of Science, 2004

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This study investigated whether pesticide residues occur inside homes of vegetable and small fruit growers, identified pesticide handling practices that could contribute to home contamination, and evaluated the impact of an educational intervention in changing those handling practices. Dust samples were collected from the subjects' homes and analyzed for chlorothalonil. Residues were detected in carpet dust samples (8-277 ng/g), floor wipe samples (0.08-5.1 ug/sq m) and one washing machine sample (1.0 ug/sq m of washing machine). Each subject received an educational intervention consisting of a personalized report noting sites contaminated and providing recommendations of handling practices that would be expected to reduce any residues. Three sequential surveys of Maryland growers provided information regarding handling practices and changes over time. Lessons from this study could be incorporated into pesticide safety education to promote safer pesticide handling.

ASSESSMENT OF PESTICIDE RESIDUES IN FARMERS' HOUSE DUST AND EDUCATIONAL INTERVENTION TO IMPROVE PESTICIDE HANDLING PRACTICES

By

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Introduction

Introduction to Pesticides

Pesticides are substances that kill, repel, or otherwise control pests including insects, weeds, animals, bacteria, viruses, and fungi. Pesticides in the agricultural setting aid in increasing crop production and cutting costs for farmers. Despite the benefits of pesticides in agriculture, some pesticides may pose a serious risk to the environment, to nontarget organisms and to human health. In addition to well-documented risks of acute toxicity from some pesticides, epidemiological studies have associated the use of various pesticides with human health risks including reproductive toxicity (Arbuckle et al. 2001), developmental effects (Loffredo et al. 2001), neurotoxic effects (Kilburn 1997), respiratory complications (Hoppin et al. 2002; Mekonnen et al. 2002), and Parkinson's Disease (Petrovitch et al. 2002). Another health risk linked to pesticide use was a higher incidence of cancer among people who live and work in agricultural areas (Schreinemachers et al. 1999). Bladder cancer (Webster et al. 2002), breast cancer (Calle et al. 2002), and Ewing's sarcoma (Valery et al. 2002) are among the cancers associated with the use of pesticides. Research by Winstead (1993) indicated that farmers who used pesticides were concerned about the many risks associated with chemical use. The environment, health, pesticide handling and the need for more pesticide health and safety education were among the farmers' concerns regarding pesticide use.

Human Exposure to Pesticides

Behaviors contributing to exposure

Assessment of questionnaires administered to 26,793 licensed private applicators enrolled in the Agricultural Health Study (AHS) by Gladen et al. (1998) revealed numerous opportunities for direct and indirect pesticide exposure to farm families. In the AHS, 27% of applicators stored pesticides in their homes, 94% of clothing worn by pesticide applicators was laundered in the same machine as other laundry, and 21% of the family homes were within 50 yards of the pesticide mixing areas. Additionally, 51% of the wives of applicators worked in the fields, 40% of wives had mixed or applied pesticides, and over half of the farm children had performed farm chores. McCauley et al. (2001) established that levels of the organophosphate insecticide azinphos-methyl in farmworker and farmer house dust were correlated with distance from agricultural fields and the number of farmworkers living in the home. Both studies illustrated increased exposure opportunities for farm families.

Interestingly, licensed pesticide applicators who reported high pesticide exposure events (HPEE) were more likely to delay several hours after work before changing their clothes and were more likely to mix their work clothes with the rest of the family laundry (Alavanja et al.1999). Likewise, these applicators were also more likely to spray near home water wells and near their homes in general. These practices were an indicator for the amount of caution an applicator used when applying pesticides, and also the amount of risk associated with pesticide use.

Other studies have shown increased pesticide exposure opportunities due to specific activities and practices. Researchers have documented pesticide residues carried into the home on work boots and other clothing (McCauley et al. 2001; Fenske et al. 2002). Assessment of behaviors of farmworker children revealed many activities leading to opportunities for pesticide exposure (Cooper et al. 2001). These activities included working in fields at a very young age, swimming in irrigation channels near treated fields during the summer, applying fertilizers, spraying weeds and insects around the home or in the family garden, and playing outside on weekends when fields were sprayed.

In addition to exposures in and around the home, farmers and farmworkers are occupationally exposed to pesticides. Farmers are exposed to pesticides during mixing, loading, and application. Farmworkers are exposed to residues through tasks such as hand weeding, hand harvesting, mowing and equipment maintenance. Simcox et al. (1999) reported that azinphos-methyl remained on apple foliage during a 6-week testing period. The pesticide residues were a potential source of continuous exposure to the apple thinners assessed in the study.

Coronado et al. (2004) identified specific farmworker activities that contributed to higher organophoshate metabolites in urine. Workers who performed mostly fieldwork related tasks (harvesting or picking, pruning, loading, packing, or sorting plants, fruits, or vegetables; weeding, thinning or irrigating) generally had higher dimethylphosphate (DMP) metabolite levels than workers who did not perform these tasks. In addition, the children of the workers who participated in thinning had higher DMP metabolite levels than children whose parents did not perform this duty. The authors noted that both the primary exposure of the workers and the secondary exposure of their children might be explained by pesticides brought home on farmworkers' clothing and boots. In addition to higher metabolite levels, these workers also had a higher probability of having detectable azinphos-methyl residue levels in their house dust. However, in general, particular tasks farmworkers performed were not good predictors of the presence of pesticide residues in their house dust.

Attention has also been focused on recognizing activity patterns related to potential non-occupational pesticide exposures. Echols et al. (2001) identified nonoccupational adult skin contact with soil and grass, as well as contact with carpet, as potential pesticide exposure opportunities. Moreover, weekends during the summer and spring were designated as critical exposure periods.

Pesticide residues in and around homes

Activities of farm families (defined as a farmer, the spouse and children) and proximity of farm homes to pesticide application areas present an opportunity for chronic exposure to agricultural pesticides. Ward et al. (2000) demonstrated that a graphic information system (GIS) could be used to predict areas around a crop field likely to be a zone for potential exposure.

Multiple studies have documented pesticide exposure occurring inside the home (Simcox et al. 1995; Gladen et al. 1998; Alavanja et al. 1999; Coronado et al. 2004). Chronic exposure is of concern for farm families residing near pesticide treated fields. Pesticide dust samples, specifically from carpet dust, can serve as an indication of long-term pesticide use and chronic exposure (Roinestad et al.1993; Lewis et al. 1994; Colt et al.1998). A pilot study of 10 farmers' homes in central New York State analyzed house settled dust samples, wipe samples and carpet dust samples for 14 non-acid pesticides and four acid pesticides in the summer of 1999 (Lemley et al. 2002). Atrazine, a commonly applied herbicide, was detected in all of the settled dust samples, and four pesticides (carbaryl, metolachlor, picloram and 2,4-D acid) were found in every carpet dust sample. Of the 18 pesticides tested for in the study, 16 were detected in the carpet dust samples but only eight pesticides were in the settled dust and wipe samples suggesting that airborne particles settle in the carpet over time. In fact, a modeling method used to estimate exposure to the insecticides chlorpyrifos and diazinon revealed that people with large carpeted areas in their homes had higher exposures to pesticides than those without large carpeted areas (Moschandreas et al. 2001). Carpeted areas in the home overshadowed other variables such as gender, pesticide use, the year a home was built, and the education level of the home occupants as predictors for pesticide exposure.

Agricultural pesticides were also found in house dust in agricultural areas in the Lower Rio Grande Valley of Texas (Mukerjee et al. 1997). Samples were taken from each home in the summer and spring. One agricultural home had a high level of malathion, an insecticide used in agriculture, in the summer whereas in the spring the values were below detection limits. This home served as an indication that higher pesticide residues may occur in homes during the spraying season. In another study, dust samples taken from households in the state of Washington had higher levels of organophosphates compared to soil samples from the same area (Simcox et al. 1995; Fenske et al. 2000). Of the farming, farmworker, and nonfarming families in the sample populations, farm families had the highest levels of detectable organophosphates in the house dust. Bradman et al. (1997) detected pesticides in 11 homes, five were residences of farmworkers. One to eight different pesticides were found in each home even though the collection area had been cleaned within the week prior to house dust collection. The highest concentrations of diazinon and chlorpyrifos were found in the farmworker home with linoleum flooring.

Household pesticide residues are not limited to homes in agricultural areas. Colt et al. (1998) collected vacuum cleaner bags from 15 homes in the Washington, DC area. The residue concentrations for common residential insecticides, fungicides and herbicides were compared to concentrations of the same pesticides collected from the same area using the HVS3, a high-volume surface sampler. Results indicated that analysis of home vacuum cleaner bags and HVS3 collection units were both adequate ways of measuring the presence of 26 pesticides. Roinestad et al. (1993) found that vacuum bag dust samples contained higher concentrations of pesticides than air samples in seven New Jersey homes. The homes were surveyed for 23 commonly used residential pesticides. Air samples and vacuum bag dust samples were collected from each home. Pesticides found in the dust samples were always found in the air samples, but the reverse was not true. Interestingly, another study reported that pesticide concentrations were higher in indoor air than in outdoor air in the same area (Whitmore et al. 1994). Lewis et al. (1999) detected 14 pesticides in household dust collected from vacuum cleaner bags, with synthetic pyrethroids appearing in the highest amounts. Colt et al. (2004) also collected vacuum cleaner bags from 513 homes in locations across the United States and detected ortho-phenylphenol, pentachlorophenol, 2,4-D, propoxur, chlorpyrifos, *cis*- and *trans*-permethrin, and DDT. In another study, the residential pesticides atrazine, diazinon, malathion, and chlorpyrifos were detected in 102 Minnesota homes using the Edwards and Lioy (EL) sampler (Lioy et al., 2000), which can be used to estimate the amount of pesticide on the surface of a carpet.

Exposure of children

The occurrence of pesticides in carpet dust samples creates a special concern for infants, toddlers and young children who spend a significant portion of their time on the floor of their family homes. Of 102 children studied in the National Human Exposure Assessment Survey/Minnesota Children's Pesticide Exposure Study, 19 children were videotaped for assessment of micro activities (Freeman et al. 2001). Potential routes of exposure for young children included hand-to-mouth activity, object-to-mouth activity and failure to wash hands before food consumption. The aforementioned practices increased the possibility for ingestion of pesticides after accumulation of pesticide residues on children's toys following routine applications in residences (Gurunathan et al. 1998). This study demonstrated post application chlorpyrifos values with dose capabilities as high as 208 ug/kg/day for a young child. As a reference dose for the aforementioned dose value, the acute aggregate risk of food exposure from chlorpyrifos is 0.41ug/kg/day for children age 1-6 years (U.S. Environmental Protection Agency 2002b). Children can also ingest pesticides after food is dropped on a contaminated floor and then consumed by the child (Rohrer et al. 2003).

Children in the agricultural community are at an even greater risk for chronic pesticide exposure than children whose family members do not participate in agricultural work or whose homes are more than one-quarter mile away from pesticide treated fields or orchards. Fenske et al. (2002) found chlorpyrifos and parathion residues in house dust samples in a central Washington State agricultural community. Homes with children were grouped into three categories: applicator homes, farm worker homes, and nonagricultural reference homes. Residues of chlorpyrifos (an agricultural insecticide) were found at the highest levels in applicator homes (0.4ug/g), followed by farm worker homes (0.3 ug/g) and lastly, nonagricultural reference homes (0.1ug/g). These levels, however, did not correspond to urinary metabolite concentrations in children living in the homes. Quandt et al. (2004) detected agricultural pesticide residues in floor samples, toy samples and hand wipe samples in farmworkers' homes in North Carolina and Virginia.

Fenske et al. (2000) also found that children with parents in the agricultural industry had azinphos-methyl dose estimates above the U.S. EPA chronic dietary reference dose (3ug/kg/day) during the spraying season. In addition, 6 of 15 targeted organophosphate pesticides were detected (within legal tolerances) in the diets of children aged 2 to 5 years (Fenske et al. 2002). The high dose estimates for children in the Fenske study were consistent with increased levels of pesticides in pesticide applicator meals during the spraying season (Melnyk et al. 1997). Further supporting the concern of chronic exposure of children in agricultural areas, Koch et al. (2002) found that concentrations of organophosphate metabolites in children in agricultural areas were higher during months of pesticide application compared to nonapplication months.

Pesticide Monitoring

Several recent studies have monitored exposure levels in farmers, farmworkers and their families. Loewenherz et al. (1997), Mills et al. (2001), and Adgate et al. (2001) found increasing amounts of organophosphate metabolites and other pesticide metabolites with decreasing subject age. Loewenherz et al. (1997) also found significantly increased concentrations of organophosphate metabolites in 90 applicator children with a median of 0.021ug/ml compared to 25 children in a reference group whose median value of 0.005 ug/ml was normal. Shealy et al. (1996) detected carbaryl, dicamba, and 2,4-D esters and amines in pesticide applicators and their families. Using gas chromatography, these researchers were able to differentiate between levels immediately after application and a gradual decrease to normal reference levels. Atrazine was detected in saliva samples of herbicide applicators using an enzyme-linked immunosorbent assay (ELISA) (Denovan et al. 2000).

The Centers for Disease Control and Prevention conducted biological monitoring of 29 contemporary–use pesticides (Barr et al. 1999). This reference range from a random sample of United States adults can be compared to explicit exposures experienced by farmers, farmworkers and their families.

Pesticide Safety

Protections through regulations and educational programs

In an effort to reduce the exposure of pesticide applicators, agricultural workers and the families of both groups, a number of educational programs and federal, state and local laws and regulations have been developed. The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) regulates all pesticide products and their labels in the U.S. Under FIFRA, certain pesticide applicators must receive training, and the "label as law" concept was introduced. Use of any pesticide in a manner not according to the label, including ignoring directions for personal protection, is illegal under FIFRA. Another statute, the Worker Protection Standard (WPS) of 1992, was established specifically to protect those who work in or on farms, forests, greenhouses, and nurseries from overexposure to harmful chemicals and to help reduce the risk of chemical poisonings (40 CFR Part 170). Requirements under WPS include exclusion of workers from areas where pesticides are being applied, establishment of restricted-entry intervals, provision of personal protective equipment (PPE) and decontamination materials, and the stipulation of safety training. PPE has been the focus of an extensive amount of research since the establishment of the WPS in 1992. Pesticide labels specify PPE to be worn during pesticide application and other tasks where workers might come into contact with pesticide residues. Despite requirements for PPE on pesticide labels, some pesticide applicators opt not to follow these specifications. Perry et al (2002) surveyed 250 dairy farmers from six counties in Wisconsin and found that up to 56.9% were not using the required protective equipment when applying three commonly used pesticides (dicamba, atrazine, and cyanazine). In fact, only about 9% of the farmers surveyed fully complied with the protective equipment standards. It is not uncommon that efforts to protect applicators, workers, and families, such as PPE requirements, do not successfully accomplish their intended goal. Studies have shown that some PPE was too uncomfortable for workers to wear on the hottest days of summer (Keifer 2000), exposure to pesticides occurred despite the use of gloves (Fenske 1988), and there was penetration of insecticides through six commonly worn fabrics (Saleh et al.1998). Criticism of evaluations of the use of PPE and other general protective measures suggested that studies should focus more on the effectiveness of an intervention in reducing exposure in actual working populations than in tightly controlled settings (Keifer, 2000).

Regardless of the numerous protective measures in place under the WPS, educational outreach is essential for groups who are occupationally exposed to pesticide residues. Interviews with farmworkers in North Carolina's Christmas tree industry revealed that the workers were not fully aware of the dangers associated with long-term exposure to pesticides (Elmore and Arcury, 2001). Respondents indicated they had been sprayed with pesticides by accident, they thought all chemicals were harmful to humans, they believed if spraying occurred only a few times a year their health risk was limited, and they also thought people perceived as frail were more susceptible to harsher health effects. Other findings by Arcury et al. (2002) described a similar naive outlook about pesticides. Twenty to 30% of workers interviewed in North Carolina thought pesticides were not harmful to themselves or their families. In addition, only 5% of the workers felt the clothes they wore provided any additional protection against the amount of exposure to pesticides, while 54% said washing clothes every time they worked gave them no additional control over their level of exposure. Austin et al. (2001) reported a similar "lack of control" attitude about preventative safety measures among farmworkers in North Carolina. However, Arcury et al. (2002) did find that a greater amount of pesticide exposure knowledge correlated with higher Perceived Pesticide Risk (PPR) scores.

Many educational programs offered in the agricultural community focus on those populations potentially exposed to pesticides frequently or at high rates, but there are also programs for those exposed to lower rates of pesticides, or exposed intermittently. Pies et al. (1997) described a program at the University of Iowa aimed at educating farm wives and farm children about agricultural chemical safety. The program's intention was to prevent unnecessary chemical poisoning caused by exposures at home, around pesticide storage areas, in and around pesticide treated fields, and through contact with the farm father or husband. Training for farm wives included instruction in the areas of laundering clothing, testing for cholinesterase level (a bioindicator of exposure to organophosphate insecticides), use of PPE, and storage of pesticides. Educational topics for young children and teenagers included safe use of agricultural chemicals. Participant evaluations of the program were encouraging, implying more educational programs like this one would be beneficial to farm communities. Similar to the community-based education in Iowa, a project for Florida nursery and fernery workers (Flocks et al. 2001), and a Washington state farmworker project (Thompson et al. 2001) combined academic researchers and community representatives in an effort to evaluate possible pesticide exposures and create opportunities for interventions. In the early stages of their studies, they found it was possible to combine the opinions of community members, workers and academic researchers for the purpose of increased community health. A similar countywide educational program launched in Minnesota demonstrated that a broad based intervention provoked an increase in the number of farmers who said they were willing to take extra protective measures when applying and handling pesticides (Mandel et al. 2000).

Interventions have not remained solely at the community level. Leung et al. (1997) developed a home health promotional program intended to evaluate the amount of behavior change resulting from interventions and recommendations by a trained volunteer staff. Home assessments covering five categories, previously identified as possible areas for environmental intervention, were performed by volunteer coaches. The five categories included in the home assessment were dust and lead control, hazardous products, indoor air pollution, moisture problems, and other special risks. Three months after the initial assessments, interventions and recommendations, behavioral change was evaluated by telephone interview. Upon evaluation, on average each household made at least 3 behavioral changes and 86% of households made at least one behavioral change. This study confirmed the opportunity for positive environmental interventions in family homes.

Recommended practices

General recommendations for clothing and gear to be worn during pesticide handling include, at a minimum, a long-sleeved shirt and long pants, shoes and socks, rubber gloves, and splash-proof eye protection (Hetzel 1996). Loosely fitting coveralls are also recommended for increased protection for all body parts except the feet, hands, neck and head (Legault 1993). Additionally, it is recommended that unlined rubber, neoprene, or barrier laminate gloves be used when handling any pesticide whether highly toxic or not (Guo et al. 2001). All unlined gloves should be washed inside and out after each use and rubber gloves should be checked for leaks. Acquavella et al. (2004) reported wearing rubber gloves effectively reduced the levels of urinary concentrations of glyphosate, a herbicide. In all cases, pesticide applicators should never wear leather or cloth gloves (Legault 1993). Leather items absorb pesticide residues and remain a constant source of potential contamination. Cotton does not provide good protection against pesticides (Legault 1993).

Other recommendations include wearing unlined rubber or neoprene boots over work shoes or in place of work shoes when applying and/or mixing pesticides (Hetzel 1996). Pant legs should be pulled down over the top of the boots to prevent spillage from entering the boots. The rubber boots should be washed with soap and water after each use. As is the case with gloves, leather boots should never be worn for pesticide application and mixing because pesticides are absorbed into the material causing chronic exposure for the applicator.

In a review article, Laughlin (1993) highlighted key aspects of decontamination of pesticide-soiled clothing. Pesticide residue removal from clothing is dependent on both the amount of residue on the clothing and the formulation and class of a pesticide. There are several general recommendations for maximum removal of all types of pesticides. When washing pesticide contaminated clothing, a prewash or presoak product is recommended to increase the amount of surfactant and/or solvent used in residue removal (Nelson et al. 1992). Pesticide contaminated clothing should be washed separately from uncontaminated clothing to prevent transfer of residues during washing (Legault 1993). A limited number of contaminated clothing items should be washed with hot water in a full washer to encourage dislodgement of particulate matter on the clothing through increased agitation (Legault 1993). If soil-repellent finished fabric is being washed, 1.25 times the recommended amount of detergent should be used (Laughlin 1993). Finally, dry cleaning is not recommended because pesticides can be recycled in the solvents and transferred to other clothing items inadvertently (Laughlin 1993).

Use of Pesticides by Maryland Vegetable and Fruit Growers

In 2002 there were 12,200 farms in Maryland covering 2,100,000 acres (Maryland Department of Agriculture 2002). Vegetable farms accounted for 44,500 acres of the total farm acreage. The five top counties in Maryland for vegetable production were Caroline County, Dorchester County, Carroll County, Baltimore County, and Prince George's County. Sweet corn covers the greatest acreage for a fresh market commodity. Other vegetables and fruits covering large acreages in Maryland include watermelons, snap beans, tomatoes, cantaloupes and greens. Fresh market fruits and vegetables cover 68.5% of the total acreage for vegetables while processing vegetables cover the remaining 31.5%. Chlorothalonil and chlorpyrifos are both recommended for use on sweet corn (McClurg et al. 1999).

Chlorothalonil is one of the most consistently used pesticides on vegetable and small fruit crops in Maryland (University of Maryland Extension faculty 2003). Produced by Syngenta Crop Protection, Inc., the two most common trade names for chlorothalonil registered for use in the U.S. are Bravo (for use on vegetables and small fruits) and Daconil (for use on turf and ornamentals). In practice, chlorothalonil is applied to a crop multiple times during a growing season and encompasses 15% of all fungicide applied (by weight) in the United States each year (U.S. Environmental Protection Agency 2002a). Application rates vary depending on the crop, but a typical rate is in the range of 1 – 3 lbs. active ingredient per acre (McClurg et al. 1999). The compound is a polychlorinated aromatic with a nitrile group on the first and third carbons (Figure 1).

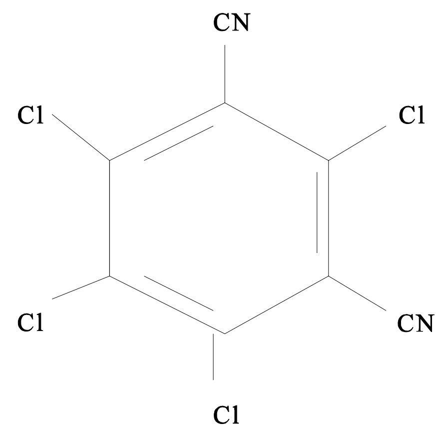

Figure 1. Chlorothalonil chemical structure

Although the compound is a chlorinated organic, the parent compound does not exhibit the same persistence in the environment as other chlorinated organics. In 1987, chlorothalonil was classified by EPA as a Group B2 or probable human carcinogen. In 1997, the EPA updated the classification as a “likely” human carcinogen by all routes of exposure. The short-term (1-7 days) and intermediate-term (1 week to several months) occupational and residential NOEL (No observed effect level) for chlorothalonil is 600 mg/kg/day.

Chlorpyrifos is also used by vegetable and small fruit growers in Maryland (Figure 2). The organophosphate insecticide is applied annually at the rate of about 10 million pounds in the US. Trade names for the pesticide include Dursban®, Lorsban®, Empire 20®, Equity®, and Whitmire PT270® (U.S. Environmental Protection Agency 2002b). As part of the pesticide class organophosphate, chlorpyrifos can cause nervous system complications such as nausea, dizziness, confusion and at severely high exposures, respiratory paralysis and death. Until 2001, chlorpyrifos was used as a residential insecticide and was considered an increased risk to children. Rates of application to vegetable and small fruit crops vary, but a typical rate is in the range of 0.5 - 1 lb. active ingredient per acre (McClurg et al. 1999).

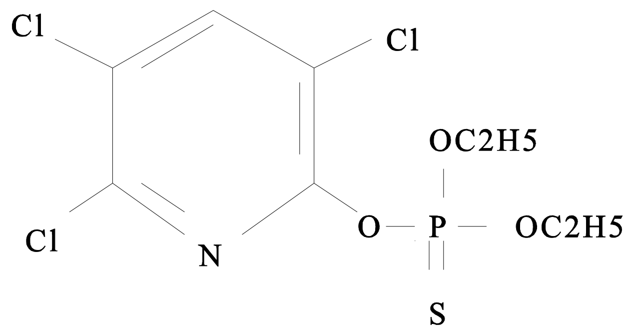

Figure 2. Chlorpyrifos chemical structure

<u>Rationale for the Study</u>

Identification of a farm family's habits, activities and high-risk exposure areas in the home can lead to opportunities for interventions. Assessment of pesticide residues in farm family residences during the spray season can indicate possible areas for increased exposure in the home. Likewise, surveys of the pesticide applicators' use of PPE, pesticide handling practices, and other related practices can provide further information regarding potential pathways of exposure both inside and outside the residence. Combination of the two assessments would allow researchers to make recommendations to the individual farm families to alter behaviors thereby reducing potential for chronic exposure. Leung et al. (1997) performed a home assessment but did not focus specifically on agricultural pesticides. Previous studies by Simcox et al. (1995), Fenske et al. (2002) and Lemley et al. (2002) reported the levels of pesticides in house dust of farmer homes but they did not offer advice on reducing the pesticide concentrations in the house dust.

This is the first study, to the researcher's knowledge, that investigated the occurrence of agricultural pesticide residues in farm family homes and made individual recommendations for behavior change intended for the reduction of pesticide exposure.

Objectives

1. Determine whether pesticide residues occur in the homes of Maryland growers.
2. Identify pesticide handlers' behaviors that increase opportunity for exposure of the grower and lead to contamination of the home and exposure of the farm family.
3. Assess whether pesticide handlers' behavior can be changed by informing them about contamination within their own homes coupled with recommendations for changing their own behaviors.

Materials and Methods

Overview

Maryland small fruit and vegetable growers were recruited to participate in the study. In June 2003, each subject was surveyed to determine demographic information, pesticides used, and pesticide handling practices. Practices that might contribute to contamination of the home were noted. During a single visit scheduled with each subject, dust samples were collected from the subjects' homes to be analyzed for pesticide residues. Chlorothalonil was chosen as the primary indicator of pesticide residue in the homes because pest management resources had indicated most Maryland vegetable and small fruit growers use this fungicide. Residue analyses were performed in the Toxicology Laboratory, Department of Entomology, University of Maryland, College Park.

After collection of the dust samples, all cooperators were surveyed again to determine whether they changed any practices relating to pesticide handling based solely on the home visit by the researchers. After the second survey was returned to the researchers, an educational intervention was performed for each subject. The intervention consisted of a personalized report noting sites contaminated, as well as recommendations of pesticide handling practices that would be expected to minimize any residues in the future. A final survey was administered during the 2004 growing season to determine if the growers changed their practices after receiving the educational intervention. To maintain confidentiality, a coding system was established on the surveys and for all other information. The study protocol was approved by the University of Maryland Institutional Review Board.

Subject Selection

Vegetable and small fruit growers were the focal point in this study. This group of farmers was chosen because they apply pesticides throughout the entire growing season, virtually all use at least a core group of the same products, and they apply pesticides themselves rather than contracting for the service. Vegetable and small fruit farmers encounter different pests during the year requiring them to use a variety of fungicides, herbicides and insecticides. The frequent use of pesticides creates the opportunity for pesticide exposure during the entire growing season. County Extension field faculty from the University of Maryland suggested the names and contact information for 25 growers in nine Maryland counties. The researchers contacted 18 growers by phone and seven growers by mail and successfully solicited participation in the study by 16 growers (all contacted by phone) to complete the entire study.

Prior to participation in the study, each participant received a thorough explanation of the study procedures including the three survey questionnaires and dust sampling. Additionally, all participants signed the informed consent form (Appendix 1) approved by the University of Maryland Institutional Review Board before returning the first survey.

With the aid of the USDA/OPMP Crop Files Database (Fournier and Brown 1999a, 1999b, 1999c, 2000a, 2000b, 2000c, 2000d; Rassmussen et al. 2002), and information from the Extension field faculty, major pests of vegetable and small fruit crops grown in Maryland were characterized and the most common pesticides used to control these pests were identified. Eighteen pesticides, including fungicides, insecticides, and herbicides were identified as being used on a scheduled basis or applied numerous times during the growing season, although not all vegetable and small fruit growers have a need for all of these pesticides. Chlorothalonil was chosen as the primary indicator of pesticide residue in the homes of subjects in this study because pest management resources had indicated chlorothalonil is used by most Maryland vegetable and small fruit growers. Consultation with University of Maryland Extension faculty indicated a large number of growers apply chlorothalonil multiple times throughout the growing season. To minimize the number of assays that would be needed to analyze residues, Maryland growers using chlorothalonil were specifically targeted to participate in the study. Chlorpyrifos was chosen as a secondary indicator of pesticide residues because (1) growers in this study were likely to use this insecticide and (2) both chlorothalonil and chlorpyrifos can be extracted and analyzed using the same analytical method (Putnam et al 2003).

Survey Administration

An initial pre-residue-sampling survey (Survey 1) (Appendix 2) was mail-administered to all participating growers in June 2003 and returned to the researchers by August 2003. This survey served as a tool to gather information regarding crops grown and pesticides used in the 2003 growing season, equipment used for pesticide application, the distance from their homes to the closest application sites, the distance from their homes to the pesticide storage areas and to the pesticide mixing and loading areas, personal pesticide handling practices including personal protective equipment (PPE) used in the field, and personal hygiene practices at home after pesticide handling. In addition, demographic information was gathered for use in describing the study participants. This survey served as the benchmark for adoption of recommended pesticide handling practices later in the study.

After the houses of participants were sampled for pesticide residues (see below), a second survey (the post-sampling survey) (Appendix 3) was mail-administered to all participants in October 2003. The purpose of this survey was to determine if any pesticide handling or personal hygiene practices had changed due to the researcher visiting and taking dust samples from the participants' home. Administering this survey enabled the researchers to use the entire subject pool as a control group for themselves.

Finally, a post-intervention survey or survey 3 (Appendix 3) was mail-administered to all study participants in June 2004. The same questionnaire was used for the post-sampling and post-intervention surveys. The purpose of the post-intervention survey (survey 3) was to evaluate any behavioral changes participants made in response to the educational intervention and residue report administered by the researchers in December 2003.

Pesticide Residue Sampling

The researcher visited the homes of the 16 study participants throughout July and August 2003 to collect dust samples. One additional household not participating in the survey portion of the study was also sampled. Participants were contacted by telephone, and a time was scheduled for the researcher to visit the residence. The subjects were asked not to vacuum the carpeted floor, wash the smooth surface floor, or clean the washing machine lid during the seven days prior to residue sampling. To allow time for cleaning of equipment and to minimize time between sample collection and storage, no more than two house dust sampling visits were scheduled on any one day. During a time agreed upon by the researcher and the cooperator, dust samples were collected from the carpeted and/or smooth surface area inside the entrance most often used by the pesticide applicator as well as from an area in the living or family room. In addition, a wipe sample was taken from the washing machine lid.

House dust from carpeted areas was collected using the HVS4, the latest version of the High Volume Small Surface Samplers originally developed for use by the U.S. EPA for collection of house dust (CS3, INC. 1998). The HVS3 has been successfully used to collect house dust samples for analysis of pesticide residues (Simcox et al. 1995; Colt et al. 1998; and Fenske et al. 2002). The updated HVS4 is lighter than the traditionally used HVS3, utilizes a canister vacuum instead of an upright vacuum, and is less expensive to purchase. The dust samples collected using the HVS4 may be analyzed for lead, pesticides and other toxic materials. Dust enters the HVS4 through the nozzle and travels into the cyclone where particles greater than 5 um are captured. About 2 g of dust can be collected in up to 10 min (U.S. Environmental Protection Agency 1998). The vacuum cleaner was adjusted according to the calibrations in the HVS4 manual. At each sampling site, a High Volume Small Surface Sampler Data Sheet was completed (Appendix 4). The cyclone catch bottle was removed from the HVS4 and used as a storage container for each sample.

At each sampling site, masking tape was placed on the floor marking off an area 75 cm wide and as long as space permitted. The masking tape was marked every 12.7 cm with a thick marker. Following the method of Lewis et al. (1994) and Fenske et al. (2002), the HVS4 was moved over the surface for a series of four passes back and forth within each 12.7 cm by 75 cm section at an approximate rate of 0.5 m/s. After the four passes, the nozzle was angled over to the next section and the process was repeated until an estimated 5 g (about ¼ of the bottle) had been collected in the catch bottle. After house dust collection, the collection bottle was removed from the vacuum, labeled and transported to the laboratory in a cooler packed with ice. The samples were maintained at 4^{o}C in a refrigerator in the lab. The HVS4 was cleaned with methanol and a brush and allowed to air dry after sampling was completed within each home.

In the case of a non-carpeted area inside the entrance way or in the living area, 100% sterile cotton gauze pads were used in a manner similar to the procedure described by Fenske et al. (2002). A metal template was used to outline a 50 cm x 50 cm smooth surface area to be wiped. Each gauze pad was treated with 1 to 2 ml of 100% isopropanol prior to wiping the surface. Using one gauze pad, the area was wiped using 3 vertical strokes followed by 3 horizontal strokes. The area on the washing machine door was sampled in a manner similar to the smooth surface floor. A 20 cm x 30 cm template was used to outline the area to be sampled on the washing machine. The template was placed on the washing machine overlapping the door edge and the lid of the machine. The gauze pad was wiped over the surface in 3 vertical strokes followed by 3 horizontal strokes. Each gauze pad was placed in a sealed bag, labeled with the subject number and date, and packed in a cooler of ice before being taken to the laboratory for analysis (Lemley et al. 2002). All samples were stored in a refrigerator in the laboratory at 4^oC.

Pesticide Residue Extraction

Extraction method pretest

Following procedures previously described for sampling carpet and bare surfaces, dust samples were taken in the home of one of the researchers and separated into two aliquots. The aliquots were spiked with 0.5 ug/g chlorothalonil and 5 ug/g of chlorothalonil, respectively, and analyzed for residues as described later. Initially, the procedure did not include the florisil clean-up step described below. However, after the extraction alone did not produce enough residues to be detected by GC/MS, the clean-up step was added.

Extraction of pesticide residues from house dust

A total of 13 carpet dust samples were analyzed. Each dust sample was weighed using an electronic balance, and the weight was recorded in a lab notebook. The sample was sieved for 5 min in a shaker using the ASTM Method D422-63 with a 100 mesh screen above the pan. To determine the weight of fine dust below 100 um, the fine dust was weighed to the nearest 0.1 g (CS3, Inc. 1998). If the amount of fine dust exceeded 5 g, 4-5 g of dust was used in the analysis and the remaining dust was stored in a 20 ml scintillation vial at 4^oC. The remaining large dust was stored in its original catch bottle in a refrigerator at 4^oC.

The fine dust was transferred to a 50 ml glass centrifuge tube. Extraction of pesticide residues took place by adding acetonitrile to the centrifuge tube in a 50 ml/ 5 g of fine dust ratio. The solution was sonicated for 1 min. Aluminum foil was then placed over the opening of the centrifuge tube, and the tube was centrifuged for 8 min at 2500 rpm. Next, 20 ml of supernatant was transferred to a second 50 ml graduated glass centrifuge tube. The pellet and the remaining supernatant were transferred to a 20 ml scintillation vial for storage. The 20 ml solution was concentrated to 5 ml under a purified argon or nitrogen stream. The 5 ml concentrated solution was stored in a scintillation vial prior to the clean-up procedure. Glass and aluminum foil were used in every step and gloves, goggles and a lab coat were worn throughout the procedure. A labeling system containing a description of the step, the code number for the sample and the date of analysis were utilized.

Wipe samples were analyzed using a similar procedure. A total of 14 floor wipe samples and 17 washing machine dust wipe samples were collected and analyzed. The gauze pads were placed in Erlenmeyer flasks containing 35 ml of acetonitrile. The flask was clamped into a wrist-action shaker. The sample was allowed to shake for 5 min, after which the gauze pads were wrung out into the flask using forceps and transferred into aluminum foil for storage at $4^{o}C$. An additional 15 ml of acetonitrile was used to rinse down the sides of the flask. Twenty ml of solution was transferred to a 50 ml graduated glass centrifuge tube and concentrated to 5 ml under a purified argon or nitrogen stream. The remaining 30 ml solution was stored in the refrigerator at $4^{o}C$ in case of need for further analysis. The 5 ml concentrated solution was stored in a 20 ml scintillation vial prior to the clean-up procedure. Again, all samples were stored in a refrigerator in the laboratory at 4°C.

To clean the sample, a florisil procedure similar to the procedure developed by Putnam et al. (2003) was used. The SPE florisil cells were placed in a chamber. Three ml of hexane were added to the SPE cell. One g of sodium sulfate was added on top of the hexane in the cell. The gauge was adjusted to allow the formation of a vacuum to pull the hexane into the chamber reservoir in a drop-wise manner. Next, the lid was removed from the chamber and a rack of centrifuge tubes was placed in the chamber reservoir. A 1 ml aliquot of the concentrated sample from the scintillation vial was pipetted into the cell. Three ml of hexane was added to the cell and a vacuum was used to pull the sample through the cell in a drop-wise manner. Five ml of 20:80 hexane:acetone was added to each cell and pulled through the cell in a drop-wise manner. The solution in the centrifuge tube was then reduced to 1 ml under an argon or nitrogen stream. Finally, the concentrate was filtered using a 0.45 um nylon screen attached to a hypodermic glass syringe. This solution was injected into a GC/MS vial and stored at 4°C until analysis. Analysis of the sample was performed using GC/MS.

Pesticide Residue Analysis

Preparation of standard solutions

A stock solution of 5 mg of chlorothalonil per 5 ml of acetonitrile was prepared. Aliquots of the stock solution were diluted in acetonitrile for use as working standard solutions. A calibration curve for the standard solutions was generated (Figure 3). A best fit line was fitted to the data points.

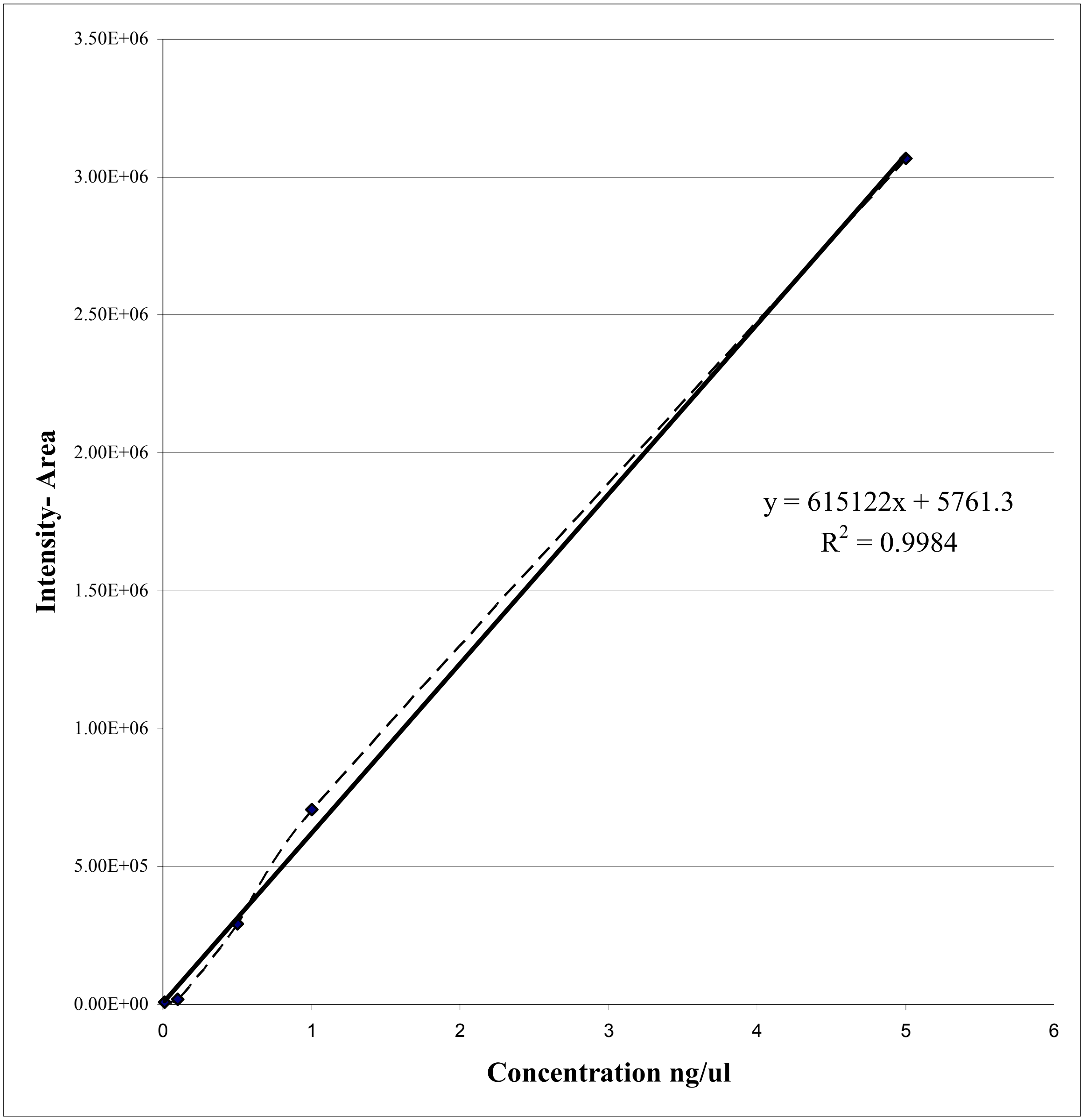

Figure 3. Calibration curve prepared of a stock solution of 5 mg of chlorothalonil per 5 ml of acetonitrile.

Analysis of residues

The samples were analyzed using gas chromatography (GC) and mass spectrometry (MS). All the samples were analyzed for chlorothalonil with the exception of one floor wipe sample and one washing machine wipe sample. Instead, these two samples were analyzed for residues of chlorpyrifos, the secondary indicator selected for this study, because the grower did not use chlorothalonil during the 2003 season.

For all samples, the AS9000 autosampler method was used, with a sample volume of 1 ul and appropriate washes in between samples. The capillary column was a 5% phenyl polysiloxane ZB-5, 30 m x 0.25 mm x 0.25 um film thickness. The analysis used splitless injection. The injection temperature was 250 ^{o}C. The oven temperature program consisted of an initial value of 60 ^{o}C held for 1 min ramped at 20 ^{o}C/min to 290 ^{o}C and held for 1 min for a total of 13.5 min. The carrier gas was helium at a rate of 40 cm/sec.

The mass spectrometer was operated in positive mode using a full scan from 50-400 amu. The source temperature was 200 ^{o}C and the transfer line was 275 ^{o}C. The start time was 3 min.

Educational Intervention and Personalized Report

After completion of dust and survey analysis, a personalized report was mailed to each study participant in December 2003 (Appendix 5). The report consisted of a letter describing the contents of the report, characterization of the residues (if any) found in the individual's home in the living area and/or on the washing machine lid, general recommendations for good pesticide handling practices, and recommendations for specific personal behavioral changes. Good handling practices were determined in consultation with the state Pesticide Safety Education Program (PSEP) Coordinator and would apply to any type of pesticide application situation. Specific recommendations for change were determined in consultation with the PSEP Coordinator based on results of practices reported by the individual subject on the pre-sampling survey.

A residue report was also sent to an additional household that did not participate in the three survey questionnaires, but had dust sampled from their home.

Statistical Analysis of Survey Answers and Residues Detected

Statistical residue analysis

All residues detected in the homes were analyzed qualitatively by describing three detection level groups for both the carpet and wipe samples. The analysis included the participant who did not complete the surveys but had dust collected. The low range residue group consisted of residue levels below the first quartile, the medium residue range consisted of levels between the first and third quartile including one value slightly above the third quartile, and the high residue group consisted of a level nearly three times higher than the other values. The wipe samples considered in the low residue range were about five times lower than wipe samples in the high residue range group.

Statistical analysis of pre-sampling, post-sampling, and post-intervention surveys

Demographic, farm and house information and activities were analyzed using descriptive statistics. All survey questions were also described using frequency tables.

The answers for behavioral practices on the pre-sampling, post-sampling, and post-intervention surveys were each given a score of 0, 1, or 2. A score of 0 indicated that the practice was "Not Recommended (NR)," a score of 1 indicated that the practice was "Acceptable (A)," and a score of 2 indicated the practice was a "Recommended (R)." Thirty-one questions were given a score for each participant in the study for a total of 496 possible answers for the study group. If a question only had two possible answers, the answers were assigned 0 (NR) or 2 (R). If a participant gave two or more answers to a specific question, the answer with the higher score was used in the analysis. The total scores for each participant for the pre-sampling, post-sampling, and post-intervention surveys were used for the comparison. The three survey scores for each applicator were compared using a completely randomized block design with the survey number as a fixed effect, each applicator as a block and the score for each survey as the response variable. Hypothesis tests and mean comparisons were performed using estimations of differences between survey scores. The hypothesis tests were performed using a Tukey-Kramer adjustment with alpha = 0.05. Logistic regression was also used to determine if a relationship existed between the presence or absence of residue and home and farm characteristics as well as spatial relationship of the home to storage, mixing/loading, and application areas.

Institutional Review and Disclaimer

Institutional review

This study was approved by the University of Maryland Institutional Review Board prior to the initiation of this study. Informed consent was obtained from each participant prior to administration of the pre-sampling survey (survey 1) and house dust sampling.

Disclaimer

The samples collected in this study were not for regulatory purposes. Analyses of the residue samples were not compared with RfD values nor did the researcher report high pesticide concentrations to any regulatory agency. It should also be noted that the study did not adhere to procedures required under Good Laboratory Practices (GLP). The data collected for the study was purely investigative and used for the purpose of influencing farm families to change pesticide handling practices in the hopes of reducing exposure to potentially harmful chemicals. Individual survey results were disclosed only to each individual subject. All data reported were pooled.

Results

Demographics

Participants

Sixteen participants agreed to have dust collected from their homes in July and August of 2003, and also completed all three survey questionnaires.

The age of primary pesticide applicators in the study ranged from 42 to 77 years old, with an average age of 51.8 years (Table 1). Only one primary applicator was female, and one participant was not a certified applicator. The average family size was 3.2 persons per home with the greatest number of people in one home being seven, while two participants resided alone. The average number of children living at home was one child and the maximum number of children under 18 was two. Seven of the 16 households (43.8%) did not have any children under 18 living at home. Three households (18.8%) reported a member of the family with a chronic health problem and one household reported general health problems during the 2003 growing season.

The average acreage of the farms was 222 acres with a range of 50-1000 acres (Table 2). The oldest house on a farm dated back to the mid-1800s, while the newest house was 12 years old; the average age was 71.3 years. On average, the participants lived in their current home for about 19 years. One applicator (6.2%) had occupied his home for 55 years while a different applicator had only lived in his current home 4 years. The age of carpets in the homes ranged from 1 year to 15 years. Fifty percent of the homes sampled had carpets that were between 6 and 10 years old. There was a fairly even distribution among use of central air conditioning, window unit air conditioner, fan, and opening the windows as methods of cooling the home.

Table 1. Participant demographics (n=16)

Characteristic	No. (%)
Age (years)	
40-49	9 (56.3)
50-59	5 (31.2)
60-69	0 (0.0)
> 70	2 (12.5)
Gender	
Male	15 (93.8)
Female	1 (6.2)
Certified applicator	
Yes	15 (93.8)
No	1 (6.2)
No. children at home under age 18	
0	7 (43.8)
1	1 (6.2)
2	8 (50.0)
No. home occupants	
1-2	6 (37.6)
3-4	8 (50.0)
5-6	1 (6.2)
7	1 (6.2)

Crops grown and pesticides used

The number of crops cultivated by the study participants ranged from 1 to 25 with an average of 12.2 different crops (Table 3). Pesticides used by subjects included 24 herbicides, 20 fungicides, 22 insecticides, and three other pesticides (Table 4). The average number of different pesticides applied before residues were collected from their homes was 20.4 with a maximum of 44 and a minimum of six.

During the entire study period, 75% of applicators used insecticides inside their homes. The pesticides were used on surfaces or on their pets. In addition, 81.2% of participants used pesticides on the lawn, the vegetable garden or the flower garden. Of the 53.8% of applicators who applied pesticides in their yard, 46.1% used them on their flower garden.

Table 2. Characteristics of the applicators' farms and homes. (n=16)

Characteristic	No. (%)
Size of farm (acres)	
0-100	5 (31.3)
101-200	4 (25.0)
201-300	6 (37.5)
>300	1 (6.2)
Years living in home	
0-10	4 (25.0)
11-20	6 (37.4)
21-30	3 (18.8)
> 30	3 (18.8)
Age of home (years)	
0-50	6 (37.5)
51-100	4 (25.0)
> 100	6 (37.5)
Age of carpet in home (years)	
N/A	2 (12.5)
1-5	4 (25.0)
6-10	8 (50.0)
11-15	2(12.5)
What method do you usually use to cool your house? [1]	
Central air conditioning	7 (43.8)
Window unit	5 (31.2)
Fan	4 (25.0)
Opening windows	5 (31.2)
Do you use a HEPA filter?	
Yes	4 (25.0)
No	11 (68.8)
N/A	1 (6.2)

[1]Some respondents reported using more than one method, thus responses do not add to 100%.

Table 3. Crops cultivated by the study participants in the 2003 growing season

Fruits	Apples Apricots Blueberries Cherries Grapes	Muskmelons Peaches Pears Plums	Strawberries Raspberries Tomatoes Watermelons
Vegetables	Asparagus Beans Beets Cole crops Cucumbers Eggplants Garlic	Greens Herbs Lettuce Okra Onions Peas Peppers	Pumpkins Radishes Spinach Summer squash Sweet corn Sweet potatoes White potatoes

Table 4. Agricultural pesticides used by growers during the 2003 growing season.

Herbicides	**Fungicides**	**Insecticides**	**Other**
2,4 D Amine	Azoxystrobin	Abamectin	Dormant Oils
Atrazine	Benomyl	Acephate	Metaldehyde bait
Bensulide	Captan	Azinphos-methyl	Streptomycin
Clomazone	Chlorothalonil	Bacillus thuringiensis	
Clopyralid	Clethodim	Bifenthrin	
DCPA	Copper, fixed	Carbaryl	
Dicamba	Cyprodinil	Carbofuran	
Diuron	Dodine	Chlorpyrifos	
Ethalfluralin	Fenarimol	Cyfluthrin	
Fluazifop	Fenbuconazole	*l*- cyhalothrin	
Glyphosate	Fenhexamid	Diazinon	
Imazethapyr	Fosetyl-aluminum	Endosulfan	
S-Metolachlor	Iprodione	Esfenvalerate	
Metribuzin	Maneb	Imidacloprid	
Napropamide	Mancozeb	Lindane	
Naptalam	Mefenoxam	Malathion	
Norflurazon	Myclobutanil	Methomyl	
Oxyfluorfen	Sulfur	Phosmet	
Paraquat	Thiophanate-methyl	Permethrin	
Pendimethalin	Thiram	Spinosad	
Sethoxydim		Tebufenozide	
Simazine		Thiamethoxam	
Terbacil			
Trifluralin			

Boom sprayers were used by all study participants (Table 5). Airblast sprayers and backpack sprayers were the next most commonly used application equipment methods.

Table 5. Application equipment used by the study participants during the 2003 growing season (n=16)

Application equipment used[1]	No. (%)
Boom sprayer	16 (100)
Airblast sprayer	13 (81.3)
Backpack sprayer	8 (50.0)
ATV sprayer	3 (18.75)
Hand pump/ hand sprayer	2 (12.5)
Wick applicator	1 (6.2)

[1]Some respondents reported using more than one method, thus responses do not add to 100%.

Location of pesticide handling areas

Distance from application site to the home varied considerably. One home (6.2%) was 50 ft from a pesticide treated field, while another home was over 2600 ft from a treated field. The average distance was about 290 ft (Table 6). More than half of the homes were upwind (with regard to prevailing winds) from the application site from the closest pesticide-treated field. The average distance to the storage area was about 780 ft while the average distance to the mixing/loading area was just over 1000 ft. No study participants reported a pesticide spill in 2003.

Table 6. Spatial relationship between homes and pesticide handling areas (n=16)

Characteristic	No. (%)
Distance from house to the pesticide storage area (feet)	
0-500	10 (62.5)
501-1000	3 (18.8)
1001-1500	1 (6.2)
>1500	2 (12.5)
Distance from house to the mixing/loading area (feet)	
0-500	9 (56.3)
501-1000	4 (25.0)
1001-1500	0 (0.0)
>1500	3 (18.7)
Distance from house to nearest application site (feet)	
0-150	11 (68.8)
151-300	4 (25.0)
301-450	0 (0.0)
> 450	1 (6.2)
Position of prevailing winds in regards to the nearest application site and the house	
Upwind from the house	9 (56.3)
Downwind from the house	7 (43.7)

Residue Analysis

Chlorothalonil was detected in 10 of 14 carpet dust samples (Table 7). The concentrations of detected residues ranged from 8-277 ng/g. Of the 12 wipe samples from the floor, three contained chlorothalonil residues, ranging from 0.08-5.1 ug/sq m. Only one wipe sample from a washing machine had a detectable residue level (1.0 ug/sq m).

Chlorpyrifos residue was not detected in the floor wipe sample and washing machine wipe sample tested.

For the purpose of reporting to the cooperators, the chlorothalonil residue levels were grouped into three categories. Using a stem and leaf plot and first and third quartile statistical information, carpet samples were assigned as follows: the low residue group consisted of levels from 8-11 ng/g, the medium group included levels from 17-95 ng/g, and the high group, consisting of one sample, was a residue level of 277 ng/g. The washing machine and floor dust wipe samples were grouped together and reported as a low level group (0.08-1.0 ug/m^2) and a high level group (5.1 ug/m^2).

Logistic regression demonstrated there was no significant relationship between the presence of residue and size of farm ($X^2 = 1.55$, $df = 1$, $p = 0.2130$), years living in the home ($X^2 = 0.0002$, $df = 1$, $p = 0.9883$), age of the home ($X^2 = 0.0029$, $df = 1$, $p = 0.9570$), or age of carpet ($X^2 = 0.1557$, $df = 1$, $p = 0.6932$). There was also no significant trend between residue and distance from the home to the pesticide storage area ($X^2 = 0.0015$, $df = 1$, $p = 0.9687$), mixing /loading area ($X^2 = 0.4525$, $df = 1$, $p = 0.5012$), or application area ($X^2 = 0.6528$, $df = 1$, $p = 0.4191$).

Table 7. Chlorothalonil residue concentrations detected in carpet and wipe dust samples (n=17)

Carpet Dust Concentration (ng/g)	Floor Wipe Dust Concentration (ug/m^2)	Washing Machine Wipe Dust Concentration (ug/m^2)
277	5.1	n.d.
95	n.d.	n.d.
83	n.d.	n.d.
63	N/A	n.d.
51	n.d.	1.0
31	N/A	n.d.
28	n.d.	n.d.
17	0.08	n.d.
11	n.d.	n.d.
8	n.d.	n.d.
n.d.	0.08	n.d.
n.d.	n.d.	n.d.
n.d.	N/A	n.d.
n.d.	n.d.	n.d.
N/A	n.d.	n.d.
N/A	n.d.	n.d.
N/A	n.d.	n.d.

Personalized Reports and Educational Intervention

The personal handling and hygiene practices participants reported using in the pre-sampling survey (Survey 1) during the 2003 growing season were used to determine changes each participant could make to decrease the risk of pesticide exposure for the applicators and their families. The researchers generated a list of 12 general recommendations encompassing all the specific behaviors addressed in the surveys that each participant could follow to provide a less risky situation for himself/herself (Appendix 5). If a practice reported by the farmer in the 31 specific behavioral questions on the pre-residue-survey sampling survey (survey 1) was not recommended or only an acceptable practice, the personalized report clearly indicated to the participant which general recommendations would be most applicable and beneficial to improving their own practices. These targeted general recommendations for each study participant are referred to in this study as the specific recommendations.

Of the 16 personalized reports sent to participants, 43.7% of participants were given one to three specific recommendations for better pesticide handling. Another 25.0% of growers were given four to six specific recommendations for positive behavior change and 31.3% were given seven to nine specific recommendations.

Farm Family Activities

Most children and spouses in the farm families did not mix, load or apply pesticides during the study period (Table 8). However, more family members engaged in scouting, harvesting, and cultivating activities. In addition to 100% of growers engaged in these activities, 25.0% of spouses and 31.3% of the participants' children participated, 37.5% of farmers used consultants, and 25% had other people including workers and pick-your-own operations.

Table 8. Frequency of applicators' spouses or children handling pesticides (n=16)

Activity	Pre-sampling survey No. (%)	Post-sampling survey No. (%)	Post-intervention survey No. (%)
How often did the pesticide applicator's **spouse mix and/or load** fungicides, herbicides, and/or insecticides?			
Always	0 (0)	0 (0)	0 (0)
More than half the time	0 (0)	0 (0)	0 (0)
Less than half the time	1 (6.2)	0 (0)	0 (0)
Never	13 (81.3)	14 (87.5)	15 (93.8)
N/A	2 (12.5)	2 (12.5)	1 (6.2)
How often did the pesticide applicator's **spouse apply** fungicides, herbicides, and/or insecticides?			
Always	0 (0)	0 (0)	0 (0)
More than half the time	0 (0)	0 (0)	0 (0)
Less than half the time	2 (12.5)	1 (6.2)	0 (0)
Never	12 (75.0)	13 (81.3)	15 (93.8)
N/A	2 (12.5)	2 (12.5)	1 (6.2)
How often did **children** under the age of 18 (your children, grandchildren, or others) **mix and/or load** fungicides, herbicides, and/or insecticides?			
Always	0 (0)	0 (0)	0 (0)
More than half the time	0 (0)	0 (0)	0 (0)
Less than half the time	0 (0)	1 (6.3)	0 (0)
Never	13 (81.2)	14 (87.5)	15 (93.8)
N/A	3 (18.8)	1 (6.2)	1 (6.2)
How often did **children** under the age of 18 (your children, grandchildren, or others) **apply** fungicides, herbicides and/or insecticides?			
Always	0 (0)	0 (0)	0 (0)
More than half the time	0 (0)	0 (0)	0 (0)
Less than half the time	1 (6.2)	1 (6.25)	1 (6.2)
Never	12 (75.0)	14 (87.25)	13 (81.3)
N/A	3 (18.8)	1 (6.25)	2 (12.5)

Three-quarters of the survey respondents reported children played on their property. Almost half of the respondents' children spent fewer than two hours outside on the farm everyday, another 41.7% reported children outside for about 2-5 hours, and 16.6% of the farm families said that children spent over five hours a day outside on the farm. The distance from the play area to the nearest application site ranged from 0 ft to 1320 ft, with an average of 230 ft. There were equal numbers of play areas reported upwind and downwind from prevailing winds.

Pesticide Handling Practices by the Primary Applicator

The majority of study participants reported wearing gloves when mixing and loading pesticides, regardless of whether the label required gloves (Table 9). However, about half of applicators never wore gloves when applying pesticides. Over half of the study participants who reported wearing gloves for either activity used a recommended barrier, rubber, neoprene, or nitrile type glove throughout the study period.

Table 9. Glove use during pesticide handling (n=16)

Behavior	**Pre-sampling survey No. (%)**	**Post-sampling survey No. (%)**	**Post-intervention survey No. (%)**
When the label **does** require gloves, how often does the pesticide applicator wear gloves when **mixing and loading**?			
Always (R)	8 (50.0)	6 (37.6)	8 (50.0)
More than half the time (A)	2 (12.5)	4 (25.0)	3 (18.7)
Subtotal of recommended/acceptable practices	10 (62.5)	10 (62.5)	11 (68.7)
Less than half the time (NR)	4 (25.0)	3 (18.7)	2 (12.6)
Never (NR)	2 (12.5)	3 (18.7)	3 (18.7)
Subtotal of non-recommended practices	6 (37.5)	6 (37.5)	5 (31.3)

When the label **does not** require gloves, how often does the pesticide applicator wear gloves when **mixing and loading**?			
Always (R)	6 (37.5)	6 (37.5)	6 (37.5)
More than half the time (A)	4 (25.0)	3 (18.7)	3 (18.7)
Subtotal of recommended/acceptable practices	10 (62.5)	9 (56.2)	9 (56.2)
Less than half the time (NR)	2 (12.5)	2 (12.5)	2 (12.5)
Never (NR)	4 (25.0)	5 (31.3)	5 (31.3)
Subtotal of non-recommended practices	6 (37.5)	7 (43.8)	7 (43.8)
When the label **does** require gloves, how often does the pesticide applicator wear gloves when **applying**?			
Always (R)	6 (37.5)	6 (37.5)	7 (43.8)
More than half the time (A)	1 (6.2)	2 (12.5)	2 (12.5)
Subtotal of recommended/acceptable practices	7 (43.7)	8 (50.0)	9 (56.3)
Less than half the time (NR)	4 (25.0)	3 (18.7)	1 (6.2)
Never (NR)	5 (31.3)	5 (31.3)	6 (37.5)
Subtotal of non-recommended practices	9 (56.3)	8 (50.0)	7 (43.7)
When the label **does not** require gloves, how often does the pesticide applicator wear gloves when **applying**?			
Always (R)	3 (18.7)	5 (31.3)	6 (37.5)
More than half the time (A)	4 (25.0)	3 (18.7)	1 (6.2)
Subtotal of recommended/acceptable practices	7 (43.7)	8 (50.0)	7 (43.7)
Less than half the time (NR)	4 (25.0)	2 (12.5)	3 (18.8)
Never (NR)	5 (31.3)	6 (37.5)	6 (37.5)
Subtotal of non-recommended practices	9 (56.3)	8 (50.0)	9 (56.3)
When the label specifies chemical-resistant gloves, what type of gloves are worn?[1, 2]			
Rubber (R)	2 (12.5)	1 (6.2)	2 (12.5)
Barrier (R)	3 (18.8)	4 (25.0)	2 (12.5)
Neoprene (R)	2 (12.5)	3 (18.8)	4 (25.0)
Nitrile (R)	6 (37.5)	4 (25.0)	3 (18.8)
Subtotal of recommended/acceptable practices	13 (81.3)	12 (75.0)	11 (68.8)
Latex/Cotton (NR)	2 (12.5)	1 (6.2)	1 (6.2)
None (NR)	2 (12.5)	2 (12.5)	3 (18.8)
Subtotal of non-recommended practices	4 (25.0)	3 (18.7)	4 (25.0)

[1]Some respondents reported using more than one method, thus responses do not add to 100%.

[2] Answer was dependent on a previous question.

Throughout the study period, the majority of applicators reported wearing long-sleeved shirts and long pants for both mixing and loading operations and for applying pesticides (Table 10). Fifty percent or more of growers also reported wearing coveralls (either Tyvek® or cotton) during mixing and loading operations. All the growers wore boots (recommended) or shoes (acceptable) during the study period, but nearly 70% consistently wore leather or canvas (not recommended).

Table 10. Clothing and footwear worn by pesticide applicators for pesticide handling activities (n=16)

Behavior	Pre-sampling survey No. (%)	Post-sampling survey No. (%)	Post-intervention survey No. (%)
What type of clothing does the pesticide applicator usually wear when **mixing and loading** pesticides?[1]			
Coveralls (Tyvek® or cotton) (R)	9 (56.4)	8 (50.0)	8 (50.0)
Long sleeve shirt/pants (A)	15 (93.8)	13 (81.2)	12 (75.0)
Subtotal of acceptable practices	15 (93.8)	13 (81.2)	12 (75.0)
Short sleeve shirt/pants (NR)	7 (43.8)	8 (50.0)	6 (37.5)
Subtotal of non-recommended practices	7 (43.8)	8 (50.0)	6 (37.5)
What type of clothing does the pesticide applicator usually wear when **applying** pesticides?[1]			
Coveralls (Tyvek® or cotton) (R)	7 (43.8)	7 (43.8)	7 (43.8)
Long sleeve shirt/pants (A)	14 (87.5)	12 (75.0)	12 (75.0)
Subtotal of acceptable practices	14 (87.5)	12 (75.0)	12 (75.0)
Short sleeve shirt/pants (NR)	7 (43.8)	8 (50.0)	7 (43.8)
Subtotal of non-recommended practices	7 (43.8)	8 (50.0)	7 (43.8)
What type of footwear does the pesticide applicator usually wear when handling pesticides?[1]			
Boots (R)	7 (43.8)	10 (62.5)	9 (56.3)
Shoes (A)	9 (56.3)	8 (50.0)	7 (43.8)
Subtotal of acceptable practices	9 (56.3)	8 (50.0)	7 (43.8)
Sandals (NR)	0 (0)	0 (0)	0 (0)
Subtotal of non-recommended practices	0 (0)	0 (0)	0 (0)

What type of footwear does the pesticide applicator usually wear when handling pesticides (material)?[1]			
Rubber (R)	4 (25.0)	6 (37.5)	5 (31.3)
Subtotal of recommended practices	4 (25.0)	6 (37.5)	5 (31.3)
Leather (NR)	10 (62.5)	10 (62.5)	9 (56.3)
Canvas (NR)	3 (18.8)	2 (12.5)	2 (12.5)
Subtotal of non-recommended practices	13 (81.3)	12 (75.0)	11 (68.8)

[1]Some respondents reported using more than one method, thus responses do not add to 100%.

The majority of the respondents reported entering directly into a main living area after handling pesticides during the 2003 growing season and maintained this activity throughout the study period (Table 11). A direct entrance included doors leading to the kitchen, family room, or living room while an indirect entrance included doors leading to a laundry room, mud room, porch, or basement. Over 60% of applicator family members also entered directly into a main living area of the house. About 70% of the applicators had a doormat at the home entrance where they entered and about 80% maintained the practice of having a rug inside the entrance. The majority of these rugs were washed after coming in contact with pesticide contaminated boots or clothing, although not necessarily soon thereafter.

Table 11. Characteristics of the primary entrance used by the applicator and the farm family (n=16)

Behavior	Pre-sampling survey No. (%)	Post-sampling survey No. (%)	Post-intervention survey No. (%)
What entrance to your house is used by the pesticide applicator after applying fungicides, herbicides, and/or insecticides or after being in a treated field?			
Indirect entrance (R)	6 (37.5)	5 (31.2)	7 (43.8)
Direct entrance (NR)	10 (62.5)	11 (68.8)	9 (56.2)

What entrance to your house is usually used by the other members of your family? Indirect entrance (R) Direct entrance (NR)	 5 (31.2) 11 (68.8)	 3 (18.8) 13 (81.2)	 6 (37.5) 10 (62.5)
Is there a doormat located outside of the primary entrance the pesticide applicator uses to enter the house? Yes (R) No (NR)	 11 (68.8) 5 (31.2)	 13 (81.2) 3 (18.8)	 13 (81.2) 3 (18.8)
Is there a rug located inside the primary entrance the pesticide applicator uses to enter the house? Yes (R) No (NR)	 14 (87.5) 2 (12.5)	 14 (87.5) 2 (12.5)	 12 (75.0) 4 (25.0)
If there is a rug, how is it used?[1] Wipe feet (R) Walk across it (NR)	 9 (56.2) 5 (31.3)	 10 (62.5) 4 (25.0)	 9 (56.2) 3 (18.8)
If there is a rug, is it removable for washing?[1] Yes (R) No (NR)	 13 (81.25) 1 (6.25)	 12 (75.0) 2 (12.5)	 11 (68.8) 1 (6.2)
If the rug is washable, how often is the rug usually washed?[1] Immediately after contact with dirty shoes or boots (R) At least once a month (R) Less frequently than once a month (A) Subtotal of recommended/acceptable practices Never (NR) Subtotal of non-recommended practices	 1 (6.2) 6 (37.5) 5 (31.3) 12 (75.0) 1 (6.2) 1 (6.2)	 1 (6.2) 7 (43.8) 3 (18.8) 11 (68.8) 1 (6.2) 1 (6.2)	 1 (6.2) 5 (31.3) 5 (31.3) 11 (68.8) 0 (0) 0 (0.0)

[1] Answer dependent on previous question

Half of the applicators consistently removed their boots before entering the house during the course of the study (Table 12). The time interval when applicators changed out of the clothing they wore while handling pesticides was variable. All applicators reported washing their hands before or immediately after entering their homes. Additionally, the majority of the applicators reported using the recommended or acceptable practice for bathing or showering after handling pesticides.

Table 12. Personal hygiene practices following the handling of pesticides reported by the study participants (n=16)

Behavior	Pre-sampling survey No. (%)	Post-sampling survey No. (%)	Post-intervention survey No. (%)
After handling pesticides, when does the pesticide applicator usually remove his/her boots/shoes?			
Before entering the house (R)	8 (50.0)	8 (50.0)	8 (50.0)
Immediately after entering the house (A)	6 (37.5)	5 (31.2)	7 (43.8)
Subtotal of recommended/acceptable practices	14 (87.5)	13 (81.3)	15 (93.8)
After entering the house but not immediately (NR)	2 (12.5)	3 (18.8)	0 (0)
Before going to bed (NR)	0 (0)	0 (0)	1 (6.2)
Subtotal of non-recommended practices	2 (12.5)	3 (18.8)	1 (6.2)
Other	0 (0)	0 (0)	0 (0)
After handling pesticides, when does the pesticide applicator usually change out of the clothes he/she wore to handle pesticides?			
Before entering the house (R)	3 (18.8)	3 (18.8)	3 (18.8)
Immediately after entering the house (A)	6 (37.5)	7 (43.7)	5 (31.2)
Before greeting spouse and/or children in the house (A)	0 (0)	0 (0)	1 (6.3)
Before sitting down in the house (A)	2 (12.5)	3 (18.8)	1 (6.2)
Subtotal of recommended/acceptable practices	11 (68.8)	13 (81.3)	10 (62.5)
Before going to bed (NR)	3 (18.7)	3 (18.7)	6 (37.5)
Subtotal of non-recommended practices	3 (18.7)	3 (18.7)	6 (37.5)
Other	2 (12.5)	0 (0)	0 (0)
After handling pesticides, when does the pesticide applicator usually wash his/her hands?			
Before entering the house (R)	11 (68.8)	10 (62.5)	12 (75.0)
Immediately after entering the house (R)	5 (31.2)	5 (31.3)	4 (25.0)
After entering the house but not immediately (A)	0 (0)	0 (0)	0 (0)
Subtotal of recommended/acceptable practices	16 (100)	15 (93.8)	16 (100)
Before going to bed (NR)	0 (0)	0 (0)	0 (0)
Subtotal of non-recommended practices	0 (0)	0 (0)	0 (0)
Other	0 (0)	1 (6.2)	0 (0)

After handling pesticides, when does the pesticide applicator usually bathe or shower?			
Before entering the house (R)	1 (6.2)	0 (0)	0 (0)
Immediately after entering the house (R)	7 (43.8)	5 (31.3)	5 (31.3)
After entering the house but not immediately (A)	4 (25.0)	5 (31.2)	5 (31.2)
Subtotal of recommended/acceptable practices	12 (75.0)	10 (62.5)	10 (62.5)
Before going to bed (NR)	4 (25.0)	6 (37.5)	6 (37.5)
Subtotal of non-recommended practices	4 (25.0)	6 (37.5)	6 (37.5)
Other	0 (0)	0 (0)	0 (0)

Over 75% of the farmers consistently reported cleaning pesticide contaminated clothing separately from household laundry and storing the clothing separately from household laundry or washing the clothing immediately after contamination occurred (Table 13). In addition, over 80% used the recommended or acceptable practices for load size and water temperature settings.

Table 13. Laundering and storage practices for the applicators' clothing worn while handling pesticides (n=16)

Behavior	Pre-sampling survey No. (%)	Post-sampling survey No. (%)	Post-intervention survey No. (%)
How are the clothes cleaned?			
Washed by a commercial firm (R)	0 (0)	0 (0)	0 (0)
Separately from household laundry (R)	12 (75.0)	13 (81.2)	14 (87.5)
Subtotal of recommended/acceptable practices	12 (75.0)	13 (81.2)	14 (87.5)
With household laundry (NR)	4 (25.0)	2 (12.5)	2 (12.5)
Dry-cleaned (NR)	0 (0)	0 (0)	0 (0)
Subtotal of non-recommended practices	4 (25.0)	3 (12.5)	2 (12.5)
Other	0 (0)	1 (6.2)	0 (0)

How are the clothes handled prior to cleaning?[1]			
Washed immediately, not stored (R)	4 (25.0)	4 (25.0)	4 (25.0)
Stored separately from household laundry (R)	10 (62.5)	8 (50.0)	10 (62.5)
Subtotal of recommended/acceptable practices	14 (87.5)	12 (75.0)	14 (87.5)
Stored with household laundry (NR)	4 (25.0)	5 (31.2)	4 (25.0)
Placed in a closet with other clothes (NR)	0 (0)	0 (0)	0 (0)
Subtotal of non-recommended practices	4 (25.0)	5 (31.2)	4 (25.0)
Other	0 (0)	0 (0)	0 (0)
What wash settings are usually used for the clothes the applicator wore while mixing, loading and/or applying pesticides?[1,2]			
(1) Water Temperature			
Hot (R)	5 (31.2)	5 (31.3)	5 (31.3)
Warm (A)	8 (50.0)	8 (50.0)	8 (50.0)
Subtotal of recommended/acceptable practices	13 (81.3)	13 (81.3)	13 (81.3)
Cold (NR)	3 (18.8)	3 (18.8)	3 (18.7)
Subtotal of non-recommended practices	3 (18.8)	3 (18.8)	3 (18.7)
(2) Load Size			
Large (R)	10 (62.5)	9 (56.2)	7 (43.8)
Medium (A)	5 (31.3)	6 (37.5)	8 (50.0)
Subtotal of recommended/acceptable practices	15 (93.8)	15 (93.8)	15 (93.8)
Small (NR)	1 (6.2)	1 (6.2)	1 (6.2)
Subtotal of non-recommended practices	1 (6.2)	1 (6.2)	1 (6.2)
(3) Cleaning Agents			
Prewash and/or presoak product (R)	2 (12.5)	3 (18.7)	2 (12.5)
Heavy-duty liquid detergent (A)	10 (62.5)	8 (50.0)	8 (50.0)
Powder detergent (A)	7 (43.7)	7 (43.7)	8 (50.0)

[1] Some respondents reported using more than one method, thus responses do not add to 100%.

[2] Water temperature, load size and cleaning agents all apply to the same question.

All of the applicators who entered their homes during the workday after handling pesticides washed their hands before entering the house or immediately after entering their house (Table 14). Of the farmers entering their homes during the day, the majority did not remove clothing worn while handling pesticides.

Table 14. Applicator practices during lunch or while taking a break on days when handling pesticides (n=16)

Behavior	Pre-sampling survey No. (%)	Post-sampling survey No. (%)	Post-intervention survey No. (%)
When handling pesticides, how often does the pesticide applicator usually enter the house for lunch or a break?			
Never (R)	3 (18.8)	3 (18.8)	5 (31.2)
One or more times a day (NR)	13 (81.2)	13 (81.2)	11 (68.8)
If once or more often a day, does the pesticide applicator usually change out of the clothing he/she wore to handle pesticides before entering the house?			
Yes (A)	3 (18.8)	1 (6.2)	2 (12.5)
No (NR)	10 (62.5)	12 (75.0)	9 (56.2)
If the pesticide applicator comes home for lunch or a break, does he/she usually wash his/her hands?			
Yes (A)	13 (81.3)	13 (81.3)	11 (68.8)
No (NR)	0 (0)	0 (0)	0 (0)

During the course of the study, participants reported that all the carpeted floors were vacuumed during the recommended or acceptable time period (Table 15). The majority of participants also washed their bare surface floors in the recommended or acceptable time interval.

Table 15. Home cleaning practices reported by the study participants (n=16)

Behavior	Pre-sampling survey No. (%)	Post-sampling survey No. (%)	Post-intervention survey No. (%)
How often are the carpets in your house usually vacuumed?			
Every day (R)	2 (12.5)	1 (6.2)	0 (0)
Once or twice a week (R)	5 (31.3)	5 (31.3)	9 (56.2)
Once or twice a month (A)	9 (56.2)	10 (62.5)	7 (43.8)
Subtotal of recommended/acceptable practices	16 (100)	16 (100)	16 (100)
Less frequently than once a month (NR)	0 (0)	0 (0)	0 (0)
Subtotal of non-recommended practices	0 (0)	0 (0)	0 (0)

How often are the bare floors in your house usually washed?			
Every day (R)	1 (6.2)	0 (0)	0 (0)
Once or twice a week (R)	3 (18.8)	1 (6.3)	4 (25.0)
Once or twice a month (A)	6 (37.5)	14 (87.5)	9 (56.2)
Subtotal of recommended/acceptable practices	10 (62.5)	15 (93.8)	13 (81.3)
Less frequently than once a month (NR)	6 (37.5)	1 (6.2)	3 (18.8)
Subtotal of non-recommended practices	6 (37.5)	1 (6.2)	3 (18.8)

Half of the study group used farm-package pesticides in their own yard or garden during the 2003 growing season (Table 16). This practice was not recommended.

Table 16. Use of farm-packaged pesticides for applicators' own yard or garden (n=16)

Behavior	**Pre-sampling survey No. (%)**	**Post-sampling survey No. (%)**	**Post-intervention survey No. (%)**
Are farm-packaged pesticides applied in your yard?			
No (R)	8 (50.0)	10 (62.5)	10 (62.5)
Yes (NR)	8 (50.0)	6 (37.5)	6 (37.5)

Statistical Analysis of the Surveys 1, 2, and 3

The difference in total scores between the pre-sampling survey (survey 1) and the post-sampling survey (survey 2) was -0.125 (+/- 1.24). The total pre-sampling survey (survey 1) scores and the total post-sampling survey (survey 2) scores were not statistically different (t = -0.10, *df* = 30, *p* = 0.9944). There was also no statistical difference between the post-sampling (survey 2) and post-intervention (survey 3) (t = -0.40, *df* = 30, *p* = 0.9143) total scores. The estimated difference in the score totals was -0.50 (+/- 1.238). The total pre-sampling survey (survey 1) scores and the total post-intervention survey (survey 3) scores were also not statistically different (t = -0.50, *df* = 30, *p* = 0.8695). The difference in scores for the two surveys was -0.625 (+/- 1.24).

Discussion and Conclusions

The mean residue level of chlorothalonil detected in this study was 66.4 ng/g in carpet dust. As a point of reference, the RfD for chlorothalonil is 0.02 mg/kg/day (U.S. Environmental Protection Agency 2002a). The RfD (Reference Dose) is used to determine a level of exposure at or below which no adverse effect is expected to occur if a substance is ingested every day over the course of a lifetime (Ware and Whitacre 2004). At the residue level detected in the carpet dust, the average adult human male would need to ingest, inhale, or otherwise absorb about 23 kg of dust per day to approach the RfD. Pesticide concentration ranges of carbaryl, chlorpyrifos and diazinon were similar in magnitude in an agricultural area in Texas (Mukerjee et al. 1997) to the chlorothalonil levels found in the current study. Also, the wipe dust samples collected in this study generally had lower magnitude pesticide residue levels compared with dust wipe samples in farmworker homes in North Carolina and Virginia (Quandt et al. 2004). The residue results in the current study were similar to previously published studies that found pesticide residues were more likely to be found in carpet dust than in wipe samples (Lemley et al. 2002, Moschandreas et al. 2001). This may explain why more carpet dust samples contained chlorothalonil residue compared with the wipe samples. Since QA methods were not used in this study for collection and transport of the dust samples, the residue levels should be considered from a qualitative, not quantitative, perspective. The results, however, can be used as an indication that pesticide residues do occur in Maryland farmers' homes and should be addressed further.

Many of the study participants were already using recommended practices in many aspects of safe pesticide handling. Collectively, the participants in the study consistently reported using good handling practices in many of the focus areas addressed in the study. Answers to 16 of the 31 behavioral questions revealed around 75% of the participants were using recommended or acceptable practices. These 16 questions could be considered evidence that product labeling and/or pesticide handling safety education are at least partially effective.

The participants consistently reported wearing chemical-resistant gloves, coveralls and/or long sleeve shirts and long pants, and boots or shoes when handling pesticides. The use of recommended or acceptable gloves, clothing and footwear illustrated that growers were taking some steps to protect themselves even though coveralls and chemical-resistant gloves can be hot and cumbersome to wear in the summer months. However, the study also revealed a trend of wearing leather or canvas shoes. Common pesticide safety education materials warn against leather and canvas shoes or boots for pesticide handling because pesticides are absorbed into the material causing a potential for chronic exposure for the applicator (Legault 1993, Hetzel 1996). Leather boots and shoes may have been easier for applicators to obtain and prefereable for other farm work. Also, the growers may have found rubber too burdensome to wear over other shoes and remove after handling pesticides.

In addition to use of PPE, the growers also removed their shoes or boots in the recommended or acceptable time interval before or after entering their homes. The aforementioned practice along with washing hands both after handling pesticides and when entering the home for lunch or a break were common practices among the participants. The growers reported washing their hands more often than a group of Americans in the general public (American Society for Microbiology 2000). A survey by the American Society for Microbiology found that 77% of surveyed Americans say they wash their hands before handling or eating food. However, the growers as a group did not remove clothing worn while handling pesticides when they entered their homes before the end of the workday. About 70% of farmers entered their homes during the day, but the majority did not remove pesticide contaminated clothing. This was not an unusual result because it is much more time consuming to change clothing when entering the home, especially if it is only for a short period of time, than it is to wash one's hands. In a study by McCauley et al (2001), over 75% of farmworkers surveyed entered their homes during the day without changing out of their work clothing. Taken together, these studies provide evidence that pesticide safety education needs to place more emphasis on the reality that clothing is also a vehicle to carry pesticide residues into homes.

Recommended or acceptable laundering practices were also common among the study participants. Growers were inclined to use the recommended or acceptable load setting and water temperature. Additionally, almost all the growers washed their clothing worn while handling pesticides separately from household laundry and also stored it separately prior to cleaning. There was a contradiction between these laundering practices and the time interval when farmers typically removed their clothing after handling pesticides. The growers seemed to recognize the risk of pesticide exposure to family members' clothing through laundering clothing together, but did not identify the risk of wearing pesticide contaminated clothing in the home for an extended time period. As with other practices in which most growers performed the recommended or acceptable practice, it was probably much more convenient for the farmers to wash and store the clothing separately than it was to change out of clothing immediately after entering the home.

A large majority of growers had a doormat outside and a rug inside the primary entrance of their homes. The rugs were removed for washing within the recommended time interval. Carpets in a large majority of the growers' homes were also vacuumed at least once or twice a month. In all these practices except for the use of chemical-resistant gloves and coveralls, there exists a very obvious pattern. The practices in which a majority of growers are using the recommended or acceptable behaviors are all practices that most normal persons would also perform in non-agricultural homes. The practices requiring extra effort, for example wearing gloves for all pesticide handling, using rubber boots over other footwear, entering the home away from a main living area (if possible), changing contaminated clothing before or immediately after entering the home, and showering or bathing as soon as possible after entering the home, were not being utilized by the growers. Excluding these activities from a daily routine could potentially increase the opportunity for exposure of the grower and lead to contamination of the home and exposure of the farm family.

In addition to the above non-recommended practices, one additional question elicited an interesting and somewhat unexpected response among the farmers. Of the study participants, half reported using farm-packaged pesticide in their own yards or gardens. This practice is not recommended because farm-packaged pesticides used in or around the home could be harmful to human health. The close proximity of application of farm-packaged pesticides to the farmers' homes could have contributed to residues found in the homes. Residues of such products used within the home may not break down inside the home in the same way as when the pesticides are applied according to the label because of the lack of heat and sunlight. Although the applicators were not asked which specific pesticides were used in the yard or garden, it is possible and highly probable that other pesticide residues were also present in the homes. Additionally, under provisions of the Federal Environmental Pesticide Control Act of 1972 which amends the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), it is unlawful for anyone to use a product inconsistent with the pesticide label (Ware and Whitacre 2004).

A one-way positive directional trend (or stasis if respondents were already utilizing best practices) would be clear evidence of improvement in practices. However, the home visit by the researchers and the educational intervention did not appear to have any effect on the final survey responses. None of the specific recommendations seemed to provoke a large number of growers to respond differently on any one question. It is important to note that because a large number of growers were already employing recommended or acceptable handling practices, a large number of improvements was not expected after the first survey. Although there was no obvious improvement in practices, a number of positive (described as an improvement in handling practices to acceptable or recommended practices) and negative (described as a practice that is not recommended) answers were identified among the three sequential surveys. Although there was no statistical difference between the overall scores in the pre-sampling survey (survey 1) and the post-sampling surveys and the pre-sampling and post-intervention surveys, changes in participants' answers did occur. A total of 24 total responses were positive changes (19 changed to the recommended practices (R)) that were maintained in both the post-sampling survey (survey 2) and post-intervention survey (survey 3). Additionally, 31 more positive changes (23 changed to the recommended practice (R)) were reported in the post-intervention survey (survey 3). However, 16 total responses were negative changes in handling practices that were reported in both the post-sampling survey (survey 2) and post-intervention survey (survey 3). An additional 28 negative changes were reported in the final survey. These discrepancies appear to be variability in responses over time. To add to the variability in survey responses, 25 questions showed a fluctuation between a specific response on the first and third surveys and a different response on the second survey. It is difficult to determine if these changes were made directly because of the recommendations made by the researchers, or if the changes were the result of random variation in the survey responses because behaviors also changed unexpectedly to not recommended practices after the home visit and the educational intervention. Overall, the respondents averaged slightly more positive changes (3.4) than negative ones (2.8). A similar study evaluating various indoor environmental pollutants by Leung et al. (1997) reported that on average each home involved in the study made at least 3 behavioral changes and 86% of the homes made at least one behavioral change. These results are very similar to the results in the current study.

There did not appear to be any clear trends as to why some participants made more positive changes than other participants. Farmers with families including two children generally made the same number of changes as families with no children under the age of 18 living at home. Similarly, age of the pesticide applicator did not seem to be a determining factor as to how many changes were made from the pre-sampling survey (Survey 1) to the post-intervention survey (Survey 3). Also, the reported presence or absence of pesticide residues in the home was not associated with making changes in handling practices. Although direct associations could not be made to explain the number of positive changes the participants made, almost 70% of the post-intervention survey (Survey 3) respondents reported making at least one of the recommended changes provided in the personalized report. Of the specific recommendations that were made in the personalized report to each participant, 31.3% of the participants did not make any of the recommended changes, 43.8% made one change, 6.2% made two changes, 12.5% made three changes, and 6.2% made four of the recommended changes.

Many educational programs offered in the agricultural community focus on different groups potentially exposed to pesticides at high rates. This study focused on the effectiveness of an intervention for primary pesticide applicators on vegetable and small fruit farms that are at a high risk of pesticide exposure because of the direct contact they have with the chemicals. Other studies, including a community-based education program in Iowa (Pies et al 1997), a project for Florida nursery and fernery workers (Flocks et al. 2001), and a Washington state farmworker project (Thompson et al. 2001) combined academic researchers and community representatives in an effort to evaluate possible pesticide exposures and create opportunities for interventions. The results of these studies, in addition to an educational program launched in Minnesota (Mandel et al. 2000), contradict the current study in which farmers did not seem to make any statistically significant changes based on the educational intervention administered by the researchers.

The study also illustrated that pesticide safety education should continue to stress the basic PPE recommendations for safe pesticide handling. The growers in this study agreed to participate in the study indicating they may have better practices than other farmers not willing to be evaluated closely, yet even some of the farmers in this study, for example, wore latex gloves or no gloves at all. Other growers wore leather boots or shoes, short-sleeved shirts or shorts and remained in pesticide contaminated clothes well after entering their homes.

Prior to this study, the pesticide handling practices of Maryland vegetable and small fruit farmers had not been directly assessed. This study provides pesticide safety educators with a better understanding of what specific areas of personal pesticide safety need to be emphasized during educational meetings and seminars. Additionally, for the purpose of educating the growers about possible risks in their own homes, and perhaps providing motivation to use recommended practices, pesticide safety educators can also inform applicators of residue levels occurring in other farm homes throughout the state.

The age structure of the participating growers likely accounted for the generally low occurrence of farm families with young children in this study. Young children may have been more incentive for participants to make the recommended changes. Instead, older growers may already be set in their ways and resistant to change. The age structure of the study group creates a situation where the study results are applicable to other older farmers in Maryland but may not apply to a younger grower age structure.

In the future, this project could be extended by collecting dust samples from the same homes in subsequent years to measure if behavioral changes impact the residue levels. This could present a difficult task because each home made different changes thus it would be hard to determine which changes influence a decrease in residues. However, it could provide information as to whether changing behaviors does have an influence on residue levels in the home. Similarly, dust samples could be collected over the course of an entire year to determine if levels vary during the growing season compared to the winter months.

Appendices

Appendix 1. IRB Approved Consent Form

Appendix 2. Survey 1: Pre-sampling survey

Appendix 3. Survey 2 and 3: Post-sampling survey and post-intervention survey

Appendix 4. HVS4 data sheet

Appendix 5. Example of personalized educational intervention report

Appendix 1. IRB Approved Consent Form

Informed Consent

Project title: **Assessment of Home Pesticide Residues and Pesticide Handling Practices**

Procedures: I understand that the procedures involve having my home sampled for pesticide residues (one time) and answering two questionnaires prepared by the researchers. The first questionnaire will be administered in late spring/early summer; the second will be administered later in the summer of 2003. The researchers will collect dust samples from an area inside the entrance most often used by the pesticide applicator, an area in the living space, and from the washing machine. Samples from carpeted areas will be collected by a vacuum; bare surfaces will be wiped with a gauze pad. Residue sampling will be conducted at a time to be arranged between the researchers and the cooperators. I understand that families cooperating in this study are asked not to vacuum the carpeted floor, wash the smooth surface floor, or clean the washing machine lid during the seven days prior to residue sampling.

Confidentiality: All information collected in the study is confidential. All identifying information will be kept in a separate password-protected file and will not be recorded on the questionnaires or on the residue collection containers. This consent form is to be mailed back separately from the questionnaire in the stamped, addressed envelopes provided, and will be maintained in a separate file from the questionnaires. I understand that answers I provide will be grouped with data other provide for scientific or educational reporting and presentation. This study is for research and education purposes only. No individual results will be provided to any regulatory agency or representative.

Risks: There are no foreseeable risks associated with participating in this study.

Benefits, freedom to withdraw and to ask question: I understand that the investigators expect to use the collated results (not individual results) to prepare educational materials that may be used in pesticide applicator training programs, which will benefit growers as a group. I will receive feedback during the course of the study on any residues in my own home, and on my own handling practices. I understand that I am free to ask questions or to withdraw from participation at any time without penalty.

Contact information: Dr. Amy Brown, Associate Professor, Department of Entomology, University of Maryland, College Park, MD 20742. Telephone no. 301-405-3928.
Consent: I state that I am over 18 years of age and wish to participate in this research project being conducted by Dr. Amy Brown in the Department of Entomology at the University of Maryland, College Park.

____________________________________ (Printed name of participant)

____________________________________ (Signature of participant) _____ (Date)

Appendix 2. Survey 1: Pre-sampling survey

Fungicide, Herbicide and Insecticide Handling Practices Survey

This survey is to be answered by the primary pesticide applicator. We greatly appreciate your time and your cooperation in this study. Because the study is for educational purposes, we ask that you please answer the survey completely and honestly. Please note that we understand there may be more than one person in your home involved in handling pesticides. We ask that all questions directed towards pesticide applicators be answered by the person who handles pesticides most often.

Subject number:____________________

Date survey completed:_________________

Pesticides Used This Season

1. Which vegetable or small fruit crops are being grown in your fields this season? (Check all that apply.)

_____Apples
_____Asparagus
_____Beans - snap or lima
_____Beets
_____Cole Crops (Broccoli, Brussel Sprouts, Cabbage, Cauliflower, Collards, Kale, or Kohlrabi)
_____Carrots
_____Celery
_____Cucumbers
_____Eggplants
_____Garlic
_____Grapes
_____Greens - mustard or turnip
_____Herbs
_____Horseradish
_____Leeks
_____Lettuce - endive or escarole
_____Muskmelons
_____Okra
_____Onions
_____Parsley
_____Parsnips
_____Peaches
_____Peas
_____Peppers
_____Pumpkins or Winter Squash
_____Radishes, Rutabagas, or Turnips
_____Spinach
_____Strawberries
_____Summer Squash or Zucchini
_____Sweet Corn
_____Sweet Potatoes
_____Tomatoes
_____Watermelons
_____White Potatoes
_____Other crops:

2. What pesticides (fungicides, herbicides, and/or insecticides) have you used in the fields this season up to now and how often have you applied them so far this season? (Circle the pesticides you have used and indicate next to the pesticide how often you have applied it so far this season (1x,2x,etc.))

______2,4-D Amine
______Acrobat (dimethomorph)
______Actara (thiamethoxam)
______Actigard (acibenzolar-S-methyl)
______Address (acephate)
______Admire (imidacloprid)
______Agree (Bacillus thuringiensis)
______Agri-Mek (abamectin)
______Agrimycin (streptomycin)
______Aim (carfentrazine)
______Alanap (naptalam)
______Aliette (fosetyl-aluminum)
______Ambush (permethrin)
______Ammo (cypermethrin)
______Asana XL (esfenvalerate)
______Assure II (quizalofop-P-ethyl)
______Atrazine
______Avaunt
______Azadirachtin
______Banvel (dicamba)
______Barracuda (permethrin)
______Basagran (bentazon)
______Baythroid (cyfluthrin)
______Benlate
______Biobit (Bacillus thuringiensis)
______Botran (dicloran)
______Bravo (chlorothalonil)
______Brigade (acephate)
______Buctril (bromoxynil)
______Cabrio
______Captan
______Capture (bifenthrin)
______Champ DP (fixed copper)
______Command (clomazone)
______Confirm (tebufenozide)
______Crymax (Bacillus thuringiensis)
______Cyrolite
______Curbit (ethalfluralin)
______Cutlass (Bacillus thuringiensis)
______Dacthal (DCPA)
______Danitol (fenpropathrin)
______Deadline (metaldehyde)
______Desicate II (endothall)
______Devrinol (napropamide)
______Diazinon
______Dimethoate
______Dipel (Bacillus thuringiensis)
______Di-Syston (disulfoton)
______Dithane (mancozeb)
______Diquat
______Dormant Oil
______Dual Magnum (S-metolachlor)
______Echo (chlorothalonil)
______Elevate (fenhexamid)
______Eptam (EPTC)
______Equus (chlorothalonil)
______Flint (trifloxystrobin)
______Flouronil (chlorothalonil)
______Formula 40 (2,4-D)
______Force (chlorpyrifos)
______Fortress (chlorethoxyfos)
______Fury (z-cypermethrin)
______Fulfill (pymetrozine)
______Furadan (carbofuran)
______Fusilade DX (fluazifop)
______Galigan (oxyfluorfen)
______Gaucho 480 (imidacloprid)
______Gavel
______Germate Plus (diazinon and lindane)
______Glyphomax Plus (glyphosate)
______Goal (oxyfluorfen)
______Gramoxone Max (paraquat)
______Guthion (azinphos-methyl)
______Imidan (phosmet)
______Intrepid
______Javelin (Bacillus thuringiensis)
______Karmex (diuron)

______Kelthane (dicofol)
______Kerb (pronamide)
______Kernal Guard (diazinon and lindane)
______Kernal Guard Supreme (permethrin)
______Ketch (Bacillus thuringiensis)
______Kickstart (diazinon and lindane)
______Lexone (metribuzin)
______Lindane
______Linex (linuron)
______Lorox (linuron)
______Lorsban (chlorpyrifos)
______Malathion
______Maneb
______Manex II (mancozeb)
______ManKocide (mancozeb)
______Manzate (mancozeb)
______Matrix (rimsulfuron)
______Mattch (Bacillus thuringiensis)
______Metaldehyde bait
______Metasystox-R (oxydemeton-methyl)
______Methoxychlor
______Micro-Tech (alachlor)
______Monitor (methamidophos)
______M-Pede (fatty acid)
______Mustang (z-cypermethrin)
______Nemacur (fenamiphos)
______NoMate
______Nova (myclobutanil)
______Partner (alachlor)
______Penncap-M (methyl parathion)
______Penncozeb (mancozeb)
______Platinum
______Poast (sethoxydim)
______Pounce (permethrin)
______Prefar (bensulide)
______Proclaim
______Prolong (Bacillus thuringiensis)
______Provado (imidacloprid)
______Prowl (pendimethalin)
______Pursuit (imazethapyr)
______Quadris (azoxystrobin)

______Kickstart Plus (permethrin)
______Knack (pyriproxyfen)
______Kocide (copper hydroxide)
______Kocide 2000 (fixed copper)
______Lannate (methomyl)
______Larvin (thiodicarb)
______Lepinox (Bacillus thuringiensis)

______Ridomil Gold (mefenoxam)
______Ridomil Gold Copper
______Ridomil Gold MZ
______Ro-Neet (cycloate)
______Ronilan (vinclozolin)
______Roundup Ultra Max (glyphosate)
______Rovral (iprodione)
______Sandea (halosulfuron)
______Savey (hexythiazox)
______Select (clethodim)
______Sencor (metribuzin)
______Sevin (carbaryl)
______Sinbar (terbacil)
______Solicam (norflurazon)
______Spin-Aid (phenmediapham)
______SpinTor (spinosad)
______Strategy (Curbit + Command)
______Stinger (clopyralid)
______Sulfur
______Switch (cyprodinil, fludioxonil)
______Syllit (dodine)
______Thimet (phorate)
______Thionex (endosulfan)
______Thiram
______Tillam (pebulate)
______Tilt (propiconazole)
______Topsin M (thiophanate-methyl)
______Touchdown (glyphosate)
______Treflan (trifluralin)
______Trigard (cryomazine)
______Trilin (trifluralin)
______Ultra Flourish (mefenoxam)
______Warrior (l-cyhalothrin)
______Vendex (fenbutatin-oxide)
______Vydate (oxamyl)
______XenTari (Bacillus thuringiensis)

3. During this season, what application equipment have you used to apply the materials checked above? (List all that apply.)

____
____
____
____
____
____
____
____

4. How far is your house from the closest field where pesticides (fungicides, herbicides and/or insecticides) are used? (Please be sure to indicate whether the distance given is in miles, yards, or feet.)

____

5. With regard to prevailing winds, is the closest field where pesticides are used upwind or downwind from your house? (Circle your answer.)

Upwind Downwind

6. How far from the house are pesticides stored? (Please be sure to indicate whether the distance given is in miles, yards, or feet.)

____

7. How far from the house is the pesticide mixing/loading area? (Please be sure to indicate whether the distance given is in miles, yards, or feet.)

____

Fungicide, Herbicide and Insecticide Handling Practices in the Field

8. When the label does require gloves, how often does the pesticide applicator wear gloves when mixing and loading? (Circle your answer.)

Always More than half of the time Less than half of the time Never

9. When the label does not require gloves, how often does the pesticide applicator wear gloves when mixing and loading? (Circle your answer.)

Always More than half of the time Less than half of the time Never

10. When the label does require gloves, how often does the pesticide applicator wear gloves when applying? (Circle your answer.)

Always More than half of the time Less than half of the time Never

11. When the label does not require gloves, how often does the pesticide applicator wear gloves when applying? (Circle your answer.)

Always More than half of the time Less than half of the time Never

12. When the label specifies chemical-resistant gloves, what type of gloves are worn? (Circle your answer.)

Cotton Neoprene Rubber Latex Barrier gloves such as 4-H

Other:____

13. What type of clothing does the pesticide applicator usually wear when mixing and loading pesticides (fungicides, herbicides, and insecticides)? (If more than one, check all that apply, and circle the primary clothing worn.)

_____Coveralls:

_____Tyvek or other impermeable fabric

_____Cotton or cotton/polyester

_____Other:____

_____Long sleeve shirt

_____Short sleeve shirt

_____Long pants

_____Shorts

_____Other:____

14. What type of clothing does the pesticide applicator usually wear when applying pesticides (fungicides, herbicides, and insecticides)? (If more than one, check all that apply, and circle the primary clothing worn.)

_____Coveralls:

_____Tyvek or other impermeable fabric

_____Cotton or cotton/polyester

_____Other:____

_____Long sleeve shirt

_____Short sleeve shirt

_____Long pants

_____Shorts

_____Other:____

15. What type of footwear does the pesticide applicator usually wear when handling (mixing, loading, or applying) fungicides, herbicides and insecticides? (If more than one, check all that apply, and circle the primary footwear worn.)

_____Shoes _____Leather

_____Boots _____Rubber

_____Sandals _____Canvas

16. How often does the pesticide applicator's spouse mix and/or load pesticides (fungicides, herbicides, and/or insecticides)? (Circle your answer.)

Not applicable (No spouse)
Always
More than half of the time
Less than half of the time
Never

17. How often does the pesticide applicator's spouse apply pesticides (fungicides, herbicides, and/or insecticides)? (Circle your answer.)

Not applicable (No spouse)
Always
More than half of the time
Less than half of the time
Never

18. How often do children under the age of 18 (your children, grandchildren or others) mix and/or load fungicides, herbicides, and/or insecticides? (Circle your answer.)

Not applicable (No children)
Always
More than half of the time
Less than half of the time
Never

18.a. What are the ages of children who mix/load pesticides?

1st Child:_______________

2nd Child:_______________

3rd Child:_______________

19. How often do children under the age of 18 (your children, grandchildren or others) apply fungicides, herbicides and/or insecticides? (Circle your answer.)

Not applicable (No children)
Always
More than half of the time
Less than half of the time
Never

19.a. What are the ages of children who apply pesticides?

1st Child:_______________

2nd Child:_______________

3th Child:_______________

4th Child:_______________

20. During the season, how much time do children under the age of 18 (your children, grandchildren, or others) spend outside on your property (the farm or the yard)?

_____Fewer than 2 hours a day

_____2-5 hours a day

_____More than 5 hours a day

20.a. If there is a play area that the children use, how far is this area from the nearest pesticide treated field?

____

20.b. If there is a play area that the children use, is it upwind or downwind (with regard to prevailing winds) from the nearest treated fields? (Circle your answer.)

Upwind Downwind

21. Is anyone in your family a certified applicator? (Circle your answer.)

Yes No

21.a. If yes, please check all certified applicators in your family:

_____Grower

_____Spouse

_____Child/children: Age(s):_________

_____Other:________________________

22. Who enters the fields for scouting, harvesting, cultivating, etc? (Check all that apply.)

_____Grower

_____Spouse

_____Child/children: Age(s):___________________________

_____Consultants

_____Other:_______________________

23. Has there been a fungicide, herbicide, and/or insecticide spill on this farm in the last year? (Circle your answer.)

No Yes

23.a. If yes, what month and year?________________________

Fungicide, Herbicide and Insecticide Handling Practices in and around the Home

24. What entrance to your house is used by the pesticide applicator after applying fungicides, herbicides, and/or insecticides or after being in a treated field? If more than one, check all that apply, and circle the primary entrance used.

The door leading into the:

_____Main living or family room

_____Basement

_____Kitchen

_____Laundry room

_____Other:_________________________________

25. What entrance to your house is usually used by the other members of your family? If more than one, check all that apply, and circle the primary entrance used.

The door leading into the:

_____Main living or family room

_____Basement

_____Kitchen

_____Laundry room

_____Other:_________________________________

26. Is there a doormat located outside of the primary entrance the pesticide applicator uses to enter the house? (Circle your answer.)

Yes No

27. Is there a rug located inside the primary entrance the pesticide applicator uses to enter the house? (Circle your answer.)

Yes No

27.a. If there is a rug, how is it used?

_____Wipe feet/shoes on it

_____Walk across it without stopping

27.b. If there is a rug, is it removable for washing? (Circle your answer.)

Yes No

27.b.i. If the rug is washable, how often is the rug usually washed?

_____Immediately after contact with dirty boots or clothing

_____At least once a month

_____Less frequently than once a month

_____Never

28. After handling pesticides, when does the pesticide applicator usually remove his/her boots/shoes?

_____Before entering the house

_____Immediately after entering the house inside the door

_____After entering the house but not immediately

_____Before going to bed

_____Other:_______________________

29. After handling pesticides, when does the pesticide applicator usually change out of the clothes he/she wore to handle pesticides?

_____Before entering the house

_____Immediately after entering the house

_____Before greeting spouse and/or children in the house

_____Before sitting down in the house

_____Before going to bed

_____Other:______________________

30. After handling pesticides, when does the pesticide applicator usually wash his/her hands?

_____Before entering the house

_____Immediately after entering the house

_____After entering the house but not immediately

_____Before going to bed

_____Other:________________________________

31. After handling pesticides, when does the pesticide applicator usually bathe or shower?

_____Before entering the house

_____Immediately after entering the house

_____After entering the house but not immediately

_____Before going to bed

_____Other:_________________________________

32. The following two questions pertain to cleaning the clothing worn by the pesticide applicator while handling pesticides: (Check all that apply and circle the most common practice.)

32.a. How are the clothes cleaned?

_____Dry-cleaned

_____Washed in the household:

  _____With household laundry

  _____Separately from household laundry

_____Washed by a commercial firm

_____Other:_______________________________________

32.b. How are the clothes handled prior to cleaning?

_____Washed immediately, not stored

_____Stored with household laundry

_____Stored separately from household laundry

_____Placed in a closet with other clothes before being laundered

_____Other:_______________________________________

33. What wash settings are usually used for the clothes the applicator wore while mixing, loading and/or applying pesticides? (Check the most commonly used settings.)

Water Temperature:

_____ Hot

_____Warm

_____Cold

Load Size:

_____Small

_____Medium

_____Large

Cleaning Agents:

_____Prewash and/or presoak product

_____Heavy-duty liquid detergent

_____Powder detergent

_____Other:______________________________

34. Who usually washes the clothes worn for handling pesticides? (If more than one, check all that apply, and circle the primary person.)

_____The pesticide applicator

_____Spouse

_____Child/children: Age(s):____________________________________

_____Other

35. When handling pesticides, how often does the pesticide applicator usually enter the house for lunch or a break? (Circle your answer.)

Never One or more times a day

35a. If once or more often a day, does the pesticide applicator usually change out of the clothing he/she wore to handle pesticides before entering the house? (Circle your answer.)

No Yes

35.b. If the pesticide applicator comes home for lunch or a break, does he/she usually wash his/her hands?

_____No, not usually

_____Yes, before entering the house

_____Yes, after entering the house

35.c. If the pesticide applicator comes home for lunch or a snack, who usually fixes the food or drinks?

_____The pesticide applicator fixes his/her own lunch

_____The spouse, a child, or other

36. Have insecticides been used inside your home in the last year? (Check all that apply.)

_____On houseplants to control insects, mites, plant diseases, etc.

_____On surfaces to control crawling pests such as ants, cockroaches, crickets, etc.

_____On carpets, pet bedding, etc. to control fleas

_____Other

_____None used inside the home in the last year

36a. If pesticides were used inside your home, what formulations were used? (Check all that apply.)

_____Sprays

_____Dusts

_____Granulars

_____Baits

_____Crack and crevice treatment

_____Other:___________________________

37. Are pesticides used in your yard (not on your crops)? (Check all that apply.)

_____In your flower garden to control insects, weeds, diseases, or other pests

_____On your vegetable garden or fruit trees to control insects, weeds, diseases, or other pests

_____On your lawn to control insects, weeds, diseases, or other pests

_____Other

_____None used in the yard

37.a. Are farm-packaged pesticides applied in your yard? (Circle your answer.)

No Yes

General Questions

38. How old is the carpet in the main living areas of your home (living room, family room, rec room)?

________Years
________Not applicable (No carpet in main living area of house)

39. How often are the carpets in your house usually vacuumed?

_____Every day

_____Once or twice a week

_____Once or twice a month

_____Less frequently than once a month

_____Not applicable (No carpet in house)

40. How often are the bare floors in your house usually washed?

_____Every day

_____Once or twice a week

_____Once or twice a month

_____Less frequently than once a month

_____Not applicable (No bare floors in house)

41. What method do you usually use to cool your house?

_____Central air conditioning

_____Air conditioning window unit

_____Fan

_____Opening the windows

42. Do you have a HEPA (High-Efficiency Particulate Air) filter for your heating system? (Circle your answer.)

No Yes

43. Has anyone in your family experienced any chronic health problems such as allergies, asthma, other respiratory ailments, fatigue, or other long term conditions over the last year? Please circle any chronic health problem that was worse while indoors. (Please answer on the back of the sheet if you need additional space.)

_____No
_____Yes: If yes, please list the medical condition and the gender and age of each person(s) affected: (Please answer on the back of the sheet if you need additional space.)

____

____

____

44. Has anyone in your family had any other general health problems over the last year?

_____No
_____Yes: If yes, please list the medical condition and the gender and age of each person(s) affected: (Please answer on the back of the sheet if you need additional space.)

____

____

____

Demographics

45. What is the gender of the primary pesticide applicator? (Circle your answer.)

Male Female

46. What is the age of the primary pesticide applicator? _________________

47. How many children (under the age of 18) live at home? _______________

48. How many people (total) live in your home? _____________

49. What is the size of your farm?

_______ Acres

50. How long have you lived in this house?

_______Years

51. How old is your house?

_______Years

Thank you for your participation in this research project. Please return this completed survey form, with the completed consent form, in the envelope provided.

Appendix 3. Survey 2 and 3: Post-sampling survey and post-intervention survey

Fungicide, Herbicide and Insecticide Handling Practices Survey

This survey is to be answered by the pesticide applicator. We greatly appreciate your time and your cooperation in this study. Because the study is for educational purposes, we ask that you please answer the survey completely and honestly. Please note that we understand there may be more than one person in your home involved in handling pesticides. We ask that all questions directed towards pesticide applicators be answered by the person who handles pesticides most often.

Subject Number:_______

Date survey completed:_________________

Please answer this survey regarding your pesticide handling practices after we visited your home on ____________________.

<u>Fungicide, Herbicide and Insecticide Handling Practices in the field</u>

1. When the label did require gloves, how often did the pesticide applicator wear gloves when mixing and loading? (Circle your answer.)

Always More than half of the time Less than half of the time Never

2. When the label did not require gloves, how often did the pesticide applicator wear gloves when mixing and loading? (Circle your answer.)

Always More than half of the time Less than half of the time Never

3. When the label did require gloves, how often did the pesticide applicator wear gloves when applying? (Circle your answer.)

Always More than half of the time Less than half of the time Never

4. When the label did not require gloves, how often did the pesticide applicator wear gloves when applying? (Circle your answer.)

Always   More than half of the time   Less than half of the time   Never

5. When the label specified chemical-resistant gloves, what type of gloves were worn? (Circle your answer.)

Cotton   Neoprene   Rubber   Latex   Barrier gloves such as 4-H

Other:____

6. What type of clothing did the pesticide applicator usually wear when mixing and loading pesticides (fungicides, herbicides, and insecticides)? (If more than one, check all that apply, and circle the primary clothing worn.)

_____Coveralls

  _____Tyvek

  _____Cotton or cotton/polyester

  _____Other:______________________________

_____Long sleeve shirt

_____Short sleeve shirt

_____Long pants

_____Shorts

_____Other:____________________________

7. What type of clothing did the pesticide applicator usually wear when he/she applied fungicides, herbicides, and insecticides? (If more than one, check all that apply, and circle the primary clothing worn.)

_____Coveralls
  _____Tyvek
  _____Cotton or Cotton/polyester
  _____Other:_________________________________
_____Long sleeve shirt
_____Short sleeve shirt
_____Long pants
_____Shorts
_____Other:______________________________

8. What type of footwear did the pesticide applicator usually wear when handling (mixing, loading, or applying) fungicides, herbicides and insecticides? (If more than one, check all that apply, and circle the primary footwear worn.)

_____Shoes	_____Leather
_____Boots	_____Rubber
_____Sandals	_____Canvas

9. How often did the pesticide applicator's spouse mix and/or load fungicides, herbicides, and/or insecticides?

Not Applicable (No Spouse)
Always
More than half of the time
Less than half of the time
Never

10. How often did the pesticide applicator's spouse apply fungicides, herbicides, and/or insecticides?

Not Applicable (No Spouse)
Always
More than half of the time
Less than half of the time
Never

11. How often did children under the age of 18 (your children, grandchildren, or others) mix and/or load fungicides, herbicides, and/or insecticides?

Not Applicable (No Children)
Always
More than half of the time
Less than half of the time
Never

11.a. What are their ages?

1st Child:________________
2nd Child:________________
3rd Child:________________

12. How often did children under the age of 18 (your children, grandchildren, or others) apply fungicides, herbicides and/or insecticides?

Not Applicable (No children)
Always
More than half of the time
Less than half of the time
Never

12.a. What are their ages?

1st Child:_______________

2nd Child:_______________

3rd Child:_______________

13. Who has entered the fields for scouting, harvesting, cultivating, etc? (Check all that apply.)

_____Grower

_____Spouse

_____Childrenage(s):_______________________

_____Consultants

_____Other

<u>Fungicide, Herbicide and Insecticide Handling Practices in and around the Home</u>

14. What entrance to your house was usually used by the pesticide applicator after applying fungicides, herbicides, and/or insecticides, or after being in a treated field? (If more than one, check all that apply, and circle the primary entrance used.)

The door leading into the:

_____Main living or family room

_____Basement

_____Kitchen

_____Laundry Room

_____Other:______________________________

What entrance to your house was usually used by the other members of your family? (If more than one, check all that apply, and circle the primary entrance used.)

The door leading into the:

_____Main living or family room

_____Basement

_____Kitchen

_____Laundry Room

_____Other:______________________________

15. Was there a doormat placed outside the primary entrance the pesticide applicator uses to enter the house? (Circle your answer.)

Yes No

16. Was there a rug placed inside the primary entrance the pesticide applicator uses to enter the house? (Circle your answer.)

Yes No

16.a. If yes, how is the rug used?

_____Wipe feet/shoes on it

_____Walk across it without stopping

16.b. If yes, is the rug removable for washing? (Circle your answer.)

Yes No

16.b.i. If the rug is washable, how often was the rug usually washed?

_____Immediately after contact with contaminated boots or clothing

_____At least once a month

_____Less than once a month

_____Never

17. After handling pesticides, when did the pesticide applicator usually remove his/her boots/shoes??

_____Before entering the house

_____Immediately after entering the house inside the door

_____After entering the house but not immediately

_____Before going to bed

_____Other:____________________

18. After handling pesticides, when did the pesticide applicator usually change out of the clothes he/she wore to handle pesticides?

_____Before entering the house

_____Immediately after entering the house

_____Before greeting spouse and/or children in the house

_____Before sitting down in the house

_____Before going to bed

_____Other:___________________________

19. After handling pesticides, when did the pesticide applicator usually wash his/her hands?

_____Before entering the house

_____Immediately after entering the house

_____After entering the house but not immediately

_____Before going to bed

_____Other:_____________________________

20. After handling pesticides, when did the pesticide applicator usually bathe or shower?

_____Before entering the house

_____Immediately after entering the house

_____After entering the house but not immediately

_____Before going to bed

_____Other:____________________________

21. The following two questions pertain to cleaning the clothing worn by the pesticide applicator while handling pesticides: (Check all that apply and circle the most common practice.)

21.a. How were the clothes cleaned?

_____Dry-cleaned

_____Washed in the household:

_____With household laundry

_____Separately from household laundry

_____Washed by a commercial firm

_____Other:______________________________

21.b. How were the clothes handled prior to cleaning?

_____Washed immediately, not stored

_____Stored with household laundry

_____Stored separately from household laundry

_____Placed in a closet with other clothes before being laundered

_____Other:_____________________________________

22. What wash settings were used for the clothes the pesticide applicator wore while mixing, loading and/or applying pesticides? (Check the most commonly used settings.)

Water temperature

_____ Hot

_____Warm

_____Cold

Load Size

_____Small

_____Medium

_____Large

Cleaning Agents

_____Prewash and/or presoak product

_____Heavy-duty liquid

_____Powdered detergent

_____Other:___________________________

23. Who has washed the clothes worn for handling pesticides? (IF more than one, check all that apply, and circle the primary person.)

_____The pesticide applicator

_____Spouse

_____ChildrenAge(s):______________________

_____Other

24. When handling pesticides, how often has the pesticide applicator entered the house for lunch or a break?

Never One or more times a day

24.a. If once or more a day, did the pesticide applicator usually change out of the clothing he/she wore to handle pesticides? (Circle your answer.)

No Yes

24.b. If the pesticide applicator came home for lunch or a break, did he/she usually wash his/her hands?

_____No, not usually

_____yes, before entering the house

_____yes, after entering the house

24.c. If the pesticide applicator came home for lunch or a snack, who usually fixed the food or drinks?

_____The pesticide applicator fixed his/her own lunch

_____Spouse, a child, or other

25. Have pesticides been used inside of your house? (Check all that apply.)

_____On houseplants to control insects, mites, plant diseases, etc

_____On surfaces to control crawling pests such as ants, cockroaches, crickets, etc

_____On carpets, pet bedding, etc. to control fleas

_____Other

_____None used inside the home

25.a. If pesticides were used inside your home, what formulations were used? (Check all that apply.)

___Sprays ___Dusts

___Granularars ___Baits

___Crack and crevice treatment

___Other:_________________

26. Have pesticides been used in your yard (not on your crops)? (Check all that apply.)

_____In your flower garden to control insects, weeds, diseases, or other pests

_____On your vegetable garden or fruit trees to control insects, weeds, diseases, or other pests

_____On your lawn to control insects, weeds, diseases, or other pests

_____Other

_____None used in the yard

26.a. Have you used farm-packaged pesticides in your yard? (Circle your answer.)

No Yes

27. How often were the carpets in your house usually vacuumed?

_____Every day

_____Once or twice a week

_____Once or twice a month

_____Less frequently than once a month

_____Not applicable (No carpet in house)

28. How often were the bare floors in your house usually washed?

_____Every day

_____Once or twice a week

_____Once or twice a month

_____Less frequently than once a month

_____Not applicable (No bare floors in house)

29. What method did you usually use to cool your house?

_____Central air conditioning

_____Air conditioning window unit

_____Fan

_____Opening the windows

Appendix 4. High Volume Small Surface Sampler Data Sheet

Operator________________________Date________________Sample ID #___________

Sampling Site_(Subject Code)____

Type of Surface: Rug___ Hardwood Floor___ Other___________________

Type of Rug: Plush___ Level loop___ Flat___ Multilevel___ Shag___

Type of Vacuum: Upright___ Canister___ Other_________________________

Last Vacuumed_____________ Temp. ___________ Humidity___________________%

Comments____

____

Location of Area Sampled:

Leak Check: Yes___ No___ 10 sec. cleaning at end: Yes___ No ___

Total Sample Time: Min. _____ sec._____

Flow Rate ___________" Nozzle Pressure Drop________________________"

Bottle final wt._________grams Tare wt._________grams Net wt.____grams

Pan & Sample: ______grams Pan Tare Wt. ______grams Net wt.___grams

Total Dust:________________ grams/m2

Fine Dust:_________________grams/m2

Cyclone Sample #: ____

Lab sample #: ____

Appendix 5. Example of personalized educational intervention report

Assessment of Home Pesticide Residues and Pesticide Handling Practices

Results for the residence located at: Street Address, City, State Zip

Residues in your household:

Due to cost considerations and the limits of detection equipment, it was not feasible to look for all of the pesticides (insecticides herbicides, fungicides, etc.) used by participants in this study. We chose chlorothalonil (Bravo) as the indicator pesticide for your home. However, this means that there could be residues in your home for other pesticides you used. Of the 17 participant homes in the study, we found residues in 11 of the homes. In your home, we found the following results:

In house dust from the primary entrance and/or main living area of your home, we found:

The floor sample from your home had residue levels in the low range of the detectable residues.

In a sample from the outside of your washing machine, we found:

No detectable residues.

It is important to note that there are no established health-based residue levels of concern for pesticides in house dust or wipe samples. In all cases, the detectable residues were below all risk-based exposure levels. Our aim in this research project is merely to determine whether residue levels do occur in the houses of Maryland vegetable producers, and to provide feedback that might help you reduce any such levels.

Specific Recommendations:

After reviewing the answers you provided on the survey questionnaire, we recommend that you review and especially consider general recommendations 1, 6, 7, and 8 below.

General Recommendations:

1. **When handling pesticides, always wear chemical-resistant gloves, even when not required by the label.** Unlined rubber and neoprene (nitrile, etc.) gloves are recommended when using all pesticides. Studies have shown that the hands are exposed more often than any other area of the body to pesticides during mixing, loading, and application. Studies have also shown that wearing gloves can reduce the contamination significantly. Cotton and leather are not recommended, as they are not chemically resistant.

2. **When handling pesticides, always wear long pants and a long-sleeved shirt.** Long clothing provides significant protection from any material spilled or drifted onto the arms and legs.

3. **When handling pesticides, always wear any special gear or clothing listed on the pesticide label.** Such gear may be necessary to protect you from acute effects (symptoms occurring within 24 - 48 hours), chronic / delayed effects (symptoms occurring months or years after an exposure, even from small doses over a long time), or allergic reactions.

4. **Do not wear any leather or cloth items (boots, gloves, cap bands, belts, etc.) when handling pesticides.** Leather and cloth absorb pesticides easily and cannot be effectively decontaminated. Wearing chemically-resistant boots (rubber or neoprene) over shoes is a good alternative, because they protect your shoes from contamination, and they can be removed easily before you enter the house.

5. **Before entering the house, remove footgear (shoes or boots) worn while working with pesticides.** Studies have shown that pesticide residues can be tracked into the house on shoes.

6. **As soon as possible after entering the house, remove all clothing, place the clothes in a bag or container separate from household laundry, and shower with soap and water.** This will prevent any residues clinging to clothing from being transferred to chairs, carpet, counters, etc, and will ensure that the household laundry does not become contaminated.

7. **Even after changing shoes, wipe your feet on a doormat outside the house, use a washable throw rug inside the primary entrance, and wash the throw rug once a week, or more often during heavy pesticide application seasons.** Rugs can help capture any remaining pesticide residues, and washing the throw rug will help prevent any residues from being tracked in by you, your family, pets, or visitors.

8. **Wash pesticide-contaminated clothing (including any clothes you wore while handling pesticides) separately from household laundry. Use hot water, a heavy duty liquid detergent, and wash a small load of pesticide-contaminated clothes, using the large load setting.** Washing clothes separately is important to prevent contamination of the rest of the clothes worn by your family. Hot water and heavy duty liquid detergents have been shown to be more effective than cooler temperatures and other types of detergents in removing most formulations of pesticides. Using the large load setting with a small number of items helps ensure that clothes are effectively washed. Also, use of a prewash product and/or presoak is recommended for additional pesticide residue removal.

9. **Dry cleaned work clothing on the line in the sunshine, or in a hot dryer.** Sunshine and heat are two important ways to reduce any remaining pesticide residues.

10. **If you take a break, make sure to wash your hands before smoking, eating, drinking, or handling foods, such as making a lunch.** Handling foods, dishes, and utensils without washing first could potentially contaminate others in the house.

11. **If you enter the house for a break, remove boots or change shoes, and consider using a towel to sit on.** These practices will help avoid transferring any residue from your clothes to surfaces in the house. If a towel is used to sit on, use a new one each day and store it with pesticide work clothes until washing (with the clothes).

12. **Make sure all people in your household or operation who handle pesticides are aware of the above recommendations.**

References Cited

1. Acquavella JF, Alexander BH, Mandel JS, Gustin C, Baker B, Chapman P, Bleeke M. Glyphosate biomonitoring for farmers and their families: Results from the Farm Family Exposure Study. Environ Health Perspect 112(3):321-326 (2004)

2. Adgate JL, Barr DB, Clayton CA, Eberly LE, Freeman NCG, Lioy PJ, Needham LL, Pellizzari ED, Quackenboss JJ, Roy A, Sexton K. Measurement of children's exposure to pesticides: analysis of urinary metabolite levels in a probability-based sample. Environ Health Perspect 109(6):583-590 (2001)

3. Alavanja MCR, Sandler DP, McDonnell CJ, Mage DT, Kross BC, Rowland AS, Blair A. Characteristics of persons who self-reported a high pesticide exposure event in the Agricultural Health Study. Environ Res Section A 80:180-186 (1999)

4. American Society for Microbiology. America's Dirty Little Secret- Our Hands: Second hand washing survey reveals Americans still don't get it. (2000) www.washup.org/page03.htm

5. Arbuckle TE, Lin Z, Mery LS. An exploratory analysis of the effect of pesticide exposure on the risk of spontaneous abortions in an Ontario farm population. Environ Health Perspect 109(8):851-857 (2001)

6. Arcury TA, Quandt SA, Russell GB.. Pesticide safety among farmworkers: perceived risk and perceived control as factors reflecting environmental justice. Environ Health Perspect 110(Suppl 2):233-240 (2002)

7. Austin C, Arcury TA, Quandt SA, Preisser JS, Saavedra RM, Cabrera LF. Training farmworkers about pesticide safety: issues of control. J Health Care Poor Und 12(2):236-248 (2001)

8. Barr DB, Barr JR, Driskell WJ, Hill Jr. RH, Ashley DL, Needham LL, Head SL, Sampson EJ. Strategies for biological monitoring of exposure for contemporary-use pesticides. Toxicol Ind Health 15:168-179 (1999)

9. Bradman MA, Harnly ME, Draper W, Seidel S, Teran S, Wakeham D, Neura R. Pesticide exposures to children from California's Central Valley: Results of a pilot study. J Exp Anal Environ Epidemiol 7(2):217-234 (1997)

10. Calle EE, Frunkin H, Henley SJ, Savitz DA, Thun MJ. Organochlorines and breast cancer risk. CA Cancer J Clin 52(5):301-309 (2002)

11. Code of Federal Regulations Title 40 – Protection of Environment, Volume 16 Chapter 1: Environmental Protection Agency, Part 170 Worker Protection Standard

12. Colt JS, Lubin J, Camann D, Davis S, Cerhan J, Severson RK, Cozen W, Hartge P. Comparison of pesticide levels in carpet dust and self-reported pest treatment practices in four U.S. cities. J Exp Anal Environ Epidemiol 14:74-83 (2004)

13. Colt JS, Zahm SE, Camann DE, Hartge P. Comparison of pesticides and other compounds in carpet dust samples collected from used vacuum cleaner bags and from a high-volume surface sampler. Environ Health Perspect 106(11):721-724 (1998)

14. Cooper SP, Darragh AR, Vernon SW, Stallones L, MacNaughton N, Robison T, Hanis C, Zahm SH. Ascertainment of pesticide exposures of migrant and seasonal farmworker children: findings from focus group. Am J Ind Med 40:531-537 (2001)

15. Coronado GD, Thompson B, Strong L, Griffith WC, Islas I. Agricultural task and exposure to organophosphate pesticides among farmworkers. Environ Health Perspect 112(2): 142-147 (2004)

16. CS_3, INC. High Volume Small Surface Sampler: HVS3. Operation Manual. (1998)

17. Denovan LA, Lu C, Hines CJ, Fenske RA. Saliva biomonitoring of atrazine exposure among herbicide applicators. Int Arch Occup Environ Health 73:457-462 (2000)

18. Echols SL, Macintosh DL, Ryan PB. Temporal patterns of activities potentially related to pesticide exposure. J Exp Anal Environ Epidemiol 11:389-397 (2001)

19. Elmore RC, Arcury TA.. Pesticide exposure beliefs among Latino farmworkers in North Carolina's Christmas tree industry. Am J Ind Med 40:153-160 (2001)

20. Fenske RA. Comparative assessment of protective clothing performance by measuring dermal exposure during pesticide applications. Appl Ind Hyg 3:207-213 (1988)

21. Fenske RA, Kissel JC, Lu C, Kalman DA, Simcox NJ, Allen EH, Keifer MC. Biologically based pesticide dose estimates for children in an agricultural community. Environ Health Perspect 108(6):515-520 (2000)

22. Fenske RA, Lu C, Simcox NJ, Loewenherz C, Touchstone J, Moate TF, Allen EH, Kissel JC. Strategies for assessing children's organophosphate pesticide exposures in agricultural communities. J Exp Anal Environ Epidemiol 10:662-671 (2000)

23. Fenske RA, Kedan G, Lu C, Fisker-Anderson JA, Curl CL. Assessment of organophoshorus pesticide exposures in the diets of preschool children in Washington State. J Exp Anal Environ Epidemiol 12:21-28 (2002)

24. Fenske RA, Lu C, Barr D, Needham L. Children's exposure to chlorpyrifos and parathion in an agricultural community in Central Washington State. Environ Health Perspect 110(5):549-553 (2002)

25. Flocks J, Clarke L, Albrecht S, Bryant C, Monaghan P, Baker H. Implementing a community-based social marketing project to improve agricultural worker health. Environ Health Perspect 109(Suppl 3):461-468 (2001)

26. Fournier A, Brown AE (Eds.) 1999a. Crop profile for tomatoes in Maryland. USDA.OPMP Crop Profiles Database. http://pestdata.ncsu.edu/CropProfiles/

27. Fournier A, Brown AE (Eds.) 1999b. Crop profile for corn (sweet) in Maryland. USDA/OPMP Crop Profiles Database. http://pestdata.ncsu.edu/CropProfiles/

28. Fournier A, Brown AE (Eds.) 1999c. Crop profile for squash in Maryland. USDA/OPMP Crop Profiles Database. http://pestdata.ncsu.edu/CropProfiles/

29. Fournier A, Brown AE (Eds.) 2000a. Crop profile for watermelons in Maryland. USDA/OPMP Crop Profiles Database. http://pestdata.ncsu.edu/CropProfiles/

30. Fournier A, Brown AE (Eds.) 2000b. Crop profile for cucumbers (fresh market) in Maryland. USDA/OPMP Crop Profiles Database. http://pestdata.ncsu.edu/CropProfiles/

31. Fournier A, Brown AE (Eds.) 2000c. Crop profile for cucumbers (pickling) in Maryland. USDA/OPMP Crop Profiles Database. http://pestdata.ncsu.edu/CropProfiles/

32. Fournier A, Brown AE (Eds.) 2000d. Crop profile for peas in Maryland. USDA/OPMP Crop Profiles Database. http://pestdata.ncsu.edu/CropProfiles/

33. Freeman NCG, Jimenez M, Reed KJ, Gurunathan S, Edwards RD, Roy A, Adgate JL, Pellizzari ED, Quackenboss J, Sexton K, Lioy PJ. Quantitative analysis of children's microactivity patterns: The Minnesota Children's Pesticide Exposure Study. J Exp Anal Environ Epidemiol 11:501-509 (2001)

34. Gladen BC, Sandler DP, Zahm SH, Kamel F, Rowland A, Alavanja MCR. Exposure opportunities of families of farmer pesticide applicators. Am J Ind Med 34:581-587 (1998)

35. Guo C, Stone J, Stahr HM, Shelley M. Effects of exposure time, material type, and granular pesticide on glove contamination. Arch Environ Contam Toxicol 41: 529-536 (2001)

36. Gurunathan S, Robson M, Freeman N, Buckley B, Roy A, Bukowski J, Lioy PJ. Accumulation of chlorpyrifos on residential surfaces and toys accessible to children. Environ Health Perspect 106(1):9-16 (1998)

37. Hetzel GH. Safe use of pesticides in agriculture. Virginia Cooperative Extension. Publication Number 442-036 (1996)

38. Hoppin JA, Umbach DM, London SJ, Alavanga MC, Sandler DP. Chemical predictors of wheeze among farmer pesticide applicators in the Agricultural Health Study. Am J Respir Crit Care Med 165(5):683-684 (2002)

39. Keifer MC. Effectiveness of interventions in reducing pesticide overexposure and poisonings. Am J of Prev Med 18(4S):80-89 (2000)

40. Kilburn KH. Chlordane as a neurotoxin in humans. South Med J 90(3):299-304 (1997)

41. Koch D, Lu C, Fisker-Anderson J, Jolley L, Fenske RA. Temporal association of children's pesticide exposure and agricultural spraying: report of a longitudinal biological monitoring study. Environ Health Perspect 110(8):829-833 (2002)

42. Laughlin J. Decontaminating pesticide protective clothing. Rev Environ Contam Toxicol 130:79-94 (1993)

43. Legault M. Agriculture pesticide protective equipment. Colorado State University Cooperative Extension. No. 5.021 (1993)

44. Lemley AT, Hedge A, Obendorf SK, Hong S, Kim J, Muss TM, Varner CJ. Selected pesticide residues in house dust from farmers' homes in Central New York State, USA. Bull Environ Contam Toxicol 69:155-163 (2002)

45. Leung R, Koenig JQ, Simcox N, van Belle G, Fenske RA, Gilbert SG. Behavioral changes following participation in a home health promotional program in King County, Washington. Environ Health Perspect 105(10):1132-1135 (1997)

46. Lewis RG, Fortmann RC, Camann DE. Evaluation of methods for monitoring the potential exposure of small children to pesticides in the residential environment. Arch Environ Cont Toxicol 26:37-46 (1994)

47. Lewis RG, Fortune CR, Willis RD, Camann DE, Antley JT. Distribution of pesticides and polycyclic aromatic hydrocarbons in house dust as a function of particle size. Environ Health Perspect 107(9):721-726 (1999)

48. Lioy PJ, Edwards RD, Freeman N, Gurunathan S, Pellizzari E, Adgate JL, QuackenbossJ, Sexton K. House dust levels of selected insecticides and a herbicide measured by the EL and LWW samplers and comparisons to hand rinses and urine metabolites. J Exp Anal Environ Epidemiol 10:327-340 (2000)

49. Loewenherz C, Fenske RA, Simcox NJ, Bellamy G, Kalman D. Biological monitoring of organophosphorus pesticide exposure among children in the agricultural workers in Central Washington State. Environ Health Perspect 105(12):1344-1353 (1997)

50. Loffredo CA, Silbergeld EK, Ferencz C, Zhang J. Association of transposition of the great artery in infants with maternal exposures to herbicides and rodenticides. Am J Epidemiol 153(6):529-536 (2001)

51. Mandel JH, Carr WP, Hilmer T, Leonard PR, Halberg JU, Sanderson WT, Mandel JS. Safe Handling of agricultural pesticides in Minnesota: results of a county-wide educational intervention. J Rural Health 16(2):148-154 (2000)

52. Maryland Department of Agriculture. Agriculture in Maryland: Summary for 2002 (2002).

53. McCauley LA, Lasarev MR, Higgins G, Rothlein J, Muniz J, Ebbert C, Phillips J. Work characteristics and pesticide exposures among migrant agricultural families: a community-based research approach. Environ Health Perspect 109(5):533-538 (2001)

54. McClurg CA, Beste CE, Bouwkamp JC, Rouse RJ, Everts KL, Linduska JL, Brown AE, Dively GP. Commercial Vegetable Production Recommendations (1999)

55. Mekonnen Y, Agonafir T. Effects of pesticide applications on respiratory health of Ethiopian farm workers. Int J Occup Environ Health 8(1):35-40 (2002)

56. Melnyk LJ, Berry MR, Sheldon LS. Dietary exposure from pesticide application on farms in the Agricultural Health Pilot Study. J Exp Anal Environ Epidemiol 7(1):61-80 (1997)

57. Mills PK, Zahm SH. Organophosphate pesticide residues in urine of farmworkers and their children in Fresno County, California. Am J Ind Med 40:571-577 (2001)

58. Moschandreas DJ, Kim Y, Karuchit S, Ari H, Lebowitz MD, O'Rourke MK, Gordon S, Robertson G. In-residence, multiple route exposures to chlorpyrifos and diazinon estimated by indirect method models. Atm Environ 35:2201-2213 (2001)

59. Mukerjee S, Ellenson WD, Lewis RG, Stevens RK, Somerville MC, Shadwisk DS, Willis RD. An environmental scooping study in the Lower Rio Grande Valley of Texas- III. Residential microenvironmental monitoring for air, house dust, and soil. Environ Int 23(5):657-673 (1997)

60. Nelson C, Laughlin J, Kim C, Rigakis K, Raheel M, Scholten L. Laundering as decontamination of apparel fabrics: Residues of pesticides from six chemical classes. Arch Environ Contam Toxicol 23: 85-90 (1992)

61. Perry MJ, Marbella A, Layde PM. Compliance with required pesticide-specific protective equipment use. Am J Ind Med 41:70-73 (2002)

62. Petrovitch H, Ross GW, Abbott RD, Sanderson WT, Sharp DS, Tanner CM, Masaki KH, Blanchette PL, Popper JS, Foley D, Launer L, White LR. Plantation work and risk of Parkinson Disease in a population-based longitudinal study. Arch Neurol 59:1787-1792 (2002)

63. Pies B, Grafft L, Kross B, Ogilvie L. Agricultural chemical safety awareness program for farm wives and children. J Agromed 4(1/2):139-143 (1997)

64. Putnam RA, Nelson JO, Clark JM. The persistence and degradation of chlorothalonil and chlorpyrifos in a cranberry bog. J Agric Food Chem. 51: 170-176 (2003)

65. Quandt SA, Arcury TA, Rao R, Snively BM, Camann DE, Doran AM, Yau AY, Hoppin JA, Jackson DS. Agricultural and residential pesticides in wipe samples from farmworker family residences in North Carolina and Virginia. Environ Health Perspect 112(3): 382-387 (2004)

66. Rassmussen H, Marcelli M, Brown AE (Eds) 2002. Crop profiles for musk melons in Maryland. USDA/OPMP Crop Profiles Database. http://pestdata.ncsu.edu/CropProfiles/

67. Rohrer CA, Hieber TE, Melnyk LJ, Berry MR. Transfer efficiencies of pesticides from household flooring surfaces to foods. J Exp Anal Environ Epidemiol 13:454-464 (2003)

68. Roinestad KS, Louis JB, Rosen, JD. Determination of pesticides in indoor air and dust. J AOAC Int 76(5):1121-1126 (1993)

69. Saleh MA, Kamel A-ED, Jones J. Penetration of household insecticides through different types of textile fabrics. Chemosph 36(7):1543-1552 (1998)

70. Schreinemachers DM, Creason JP, Garry VF. Cancer mortality in agricultural regions of Minnesota. Environ Health Perspect 107(3):205-211 (1999)

71. Shealy DB, Bonin MA, Wooten JV, Ashley DL, Needham LL. Application of an improved method for the analysis of pesticides and their metabolites in the urine of farmer applicators and their families. Environ Int 22(6):661-675 (1996)

72. Simcox NJ, Fenske RA, Wolz SA, Lee I-C, Kalman DA. Pesticides in household dust and soil: exposure pathways for children of agricultural families. Environ Health Perspect 102(12):1126-1134 (1995)

73. Simcox NJ, Camp J, Kalman D, Stebbins A, Bellemy G, Lee I-C, Fenske RA. Farmworker exposure to organophosphorus pesticide residues during apple thinning in Central Washington State. AIHA J 60:752-761 (1999)

74. Thompson B, Coronado G, Puschel K, Allen E. Identifying constituents to participate in a project to control pesticide exposure in children of farmworkers. Environ Health Perspect 109(Suppl 3): 443-448 (2001)

75. University of Maryland Extension faculty, personal communication, College Park, MD (2003)

76. U.S. Environmental Protection Agency. Office of Prevention, Pesticides, and Toxic Substances. Series 875-Occupational and Residential Exposure Test Guidelines. Group B- Post application exposure monitoring test guidelines. Version 5.4. (1998)

77. U.S. Environmental Protection Agency. Office of Prevention, Pesticides and Toxic Substances. Interim Reregistration Eligibility Decision for Chlorothalonil (2002a)

78. U.S. Environmental Protection Agency. Office of Prevention, Pesticides and Toxic Substances. Interim Reregistration Eligibility Decision for Chlorpyrifos (2002b)

79. Valery PC, McWhirter W, Sleigh A, Williams G, Bain C. Farm exposures, parental occupation, and risk of Ewing's sarcoma in Australia: a national case-control study. Cancer Causes Control 13(3):263-270 (2002)

80. Ward MH, Nuckols JR, Weigel SJ, Mazwell SK, Cantor KP, Miller RS. Identifying populations potentially exposed to agricultural pesticides using Remote Sensing and a Geographic Information System. Environ Health Perspect 108(1):5-12 (2000)

81. Ware GW and Whitacre DM. The Pesticide Book. MeisterPro Information Resources: Willoughby, Ohio (2004) page 242, 270.

82. Webster LR, McKenzie GH, Moriarty HT. Organophosphate-based pesticides and genetic damage implicated in bladder cancer. Canc Gen Cytog 133:112-117 (2002)

83. Whitmore RW, Immerman FW, Camann DE, Bond AE, Lewis RG, Schaum JL. Non-occupational exposures to pesticides for residents of two U.S. cities. Arch Environ Contam Toxicol 26:47-59 (1994)

84. Winstead CB. How pesticides are handled in a rural North Carolina county. AAOHN J 41(1):24-32 (1993)