A Survey of Use and Laundering Practices for Garments Worn by Pesticide Applicators

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Abstract

Pesticide applicator garments and laundering habits were assessed in late 2016 and early 2017 during continuing education programs. Paper-based surveys were administered in California, Colorado, Iowa, Maryland, and Washington state. In Colorado, data were also collected electronically using an audience response system. Shirts and pants continue to be the most commonly worn garments by pesticide applicators (72%). A small percentage wore reusable cloth (10%) or disposable (15%) coveralls. An even smaller number wore rain suits (3%). Most of the contaminated garments (78%) were washed at home. Top-load washing machines with either hot or warm water were the most common, and more people used dryers compared to line drying.

Keywords: decontamination, laundering, pesticides, protective clothing, work clothing

Introduction

In the United States, agricultural pesticide handlers, which include applicators, are required to wear at a minimum the personal protective equipment (PPE) specified on the pesticide product label. Based on the PPE information obtained in 2012 from 1,868 labels of pesticide products registered by the U.S. Environmental Protection Agency (EPA), 1,583 required a long-sleeved shirt and long pants (~85%), 128 required coveralls worn over a short-sleeved shirt and shorts (~7%), 152 required coveralls worn over a long-sleeved shirt and long pants (~8%), and five required chemical-resistant suits (~0.3%) (Shaw and Harned, 2013).

The responsibility of cleaning pesticide-contaminated clothing is determined by whether the clothing is classified as PPE or work clothing. According to the EPA Agricultural Worker Protection Standard, "*When personal protective equipment is specified by the labeling of any pesticide for any handling activity, the handler employer shall provide the appropriate personal protective equipment in clean and operating condition to the handler*" (e-CFR; italics added). Thus, unless a single-use coverall is provided, the employer is responsible for ensuring that the PPE provided is cleaned. However, "*Long-sleeved shirts, short-sleeved shirts, long pants, short pants, shoes, socks, and other items of work clothing are not considered personal protective*

equipment" (e-CFR; italics added). Therefore, the handler is responsible for cleaning his or her work clothing.

The importance of the handler's responsibility to clean the contaminated work clothing is highlighted by the fact that approximately 85% of the labels require only a long-sleeved shirt and long pants (Shaw and Harned, 2013), not PPE coveralls or rain suits. Contaminated work clothing is generally washed where the applicator's uncontaminated clothing is also washed, either at home or at a laundromat. Contaminated cloth coveralls (PPE) are typically either washed onsite (at work) where the washer is used mostly to clean contaminated clothing or are sent to an industrial laundering facility.

According to a survey conducted in 2000 by Tondl and Schulze (Tondl and Schulze, 2000), clothing typically worn by pesticide handlers in Nebraska was a long-sleeved shirt, jeans or work pants, and long-sleeved coveralls. The study also reported that 95% of the respondents laundered contaminated clothing at home. The high percentage reported for home laundering supports Shaw's label data (Shaw and Harned, 2013), in which 85% of pesticide product labels required only shirt and pants, which are the applicator's responsibility to clean.

Pesticide label precautionary statements related to cleaning often provide very limited information. "Follow manufacturer's instructions for cleaning/maintaining PPE. If no such instructions for washables, use detergent and hot water. Keep and wash PPE separately from other laundry" or very similar wording is stated on the label. As work clothing is not considered PPE, no laundering guidance is provided for approximately 85% of the garments worn by pesticide applicators. Even if the precautionary statement were to include cleaning instructions for work clothes, following manufacturer's instructions would be questionable since washing instructions on garment labels are not intended for cleaning pesticide-contaminated clothing.

Laundering pesticide-contaminated clothing is critical for reducing pesticide handlers' short- and long-term exposure to pesticides and for preventing or minimizing residue cross-contamination onto other, uncontaminated clothing. In the last two decades, there have been significant changes in pesticide formulations, types of washing machines, wash water temperatures, cleaning products, and fabric finishes. Given below are examples of some major changes that may affect the removal of pesticides from garments.

- Due to environmental concerns, use of phosphates in laundry detergents sold in the United States is banned. Previously, phosphates were used to increase cleaning efficiency.
- To conserve energy and water, high efficiency (HE) top-load and front-load washing machines use less water. It is not known how this will affect pesticide removal from garments and residue removal from the machine. Moreover, since the mechanics of washing have changed, the recommendation of washing at the highest water setting is questionable for HE machines with no agitator.
- Household hot water temperatures are lower today compared to those of earlier laundering studies.

- Functional fabric finishes may be applied to work clothing and protective clothing worn by pesticide applicators, which may affect performance, use, and care.

As stated in the EPA guidance manual published in 1993, "*Decontamination is the removal of unwanted chemical from PPE rendering it safe for doffing, reuse, disposal, or some other post decontamination action. In practice, total removal of the contaminant is rare. Although the residues may be so low as to be inconsequential, uncertainty about the residue level is a continuing problem"* (EPA, 1993; italics added). With no further research on the subject, the uncertainty about the amount of pesticide remaining in the garment after laundering remains a problem.

This paper presents findings of a survey that was conducted to better understand current applicator habits, including the types of clothing worn, who is cleaning them, and how they are currently being cleaned. The findings of this survey will assist in planning future decontamination/laundering studies. Future research will focus on (a) determining whether the amount of pesticide remaining in the garment after laundering is of concern and (b) developing scientifically supported laundering/decontamination procedures for pesticide-contaminated washable garments. The ultimate goal is to update pesticide applicator training resources (such as factsheets and presentations) for laundering work clothing (pants and shirts) and PPE (cloth coveralls).

Materials and Methods

A survey (questionnaire) was developed to collect information about types of protective clothing worn by certified pesticide applicators and the laundering practices they used. The draft was circulated for comments among the authors and selected state pesticide regulatory officials in late 2015. Subsequent changes were made following administration of the beta test questionnaire as part of applicator training in Washington state (119 responses) and Colorado (25 responses). The revised version was used by Pesticide Safety Education Program coordinators in California, Colorado, Iowa, Maryland, and Washington for data collection.

During the winter of 2016−2017, paper-based surveys were completed at seven locations in California, three in Colorado, 91 in Iowa, one in Maryland, and five in Washington. Data from these questionnaires were transferred to Excel® files and sent back to the respective states for review. These files included the location/county of the data collected. An Access® database was used to compile electronic and paper survey data for all states. The responses were tallied and reported as numbers and percentages.

A few modifications were made to the survey administered in Colorado: (a) private and commercial applicator categories were separated under certified applicator, (b) the technician option was combined with other, and (c) garments not machine-washed was excluded as temperature selection was required only if the garments were machine-washed. Colorado also required responders to specify top-load agitator or top-load high efficiency (HE) rather than just respond as top load. Data collected for the two categories in Colorado are included in the results and discussion. Data were also collected from more than 500 Colorado pesticide applicators in 15 training sessions

using an audience response system (ARS). Paper-based and ARS data collection results for Colorado were reported separately since only aggregate data are collected using ARS. An advantage of using ARS is the opportunity for follow-up discussion after the responses are displayed on the screen. The disadvantages are that additional data analysis is not possible with aggregates and the total number of responses varies considerably.

Results and Discussion

Individuals attending pesticide applicator training include some participants who do not actively apply pesticides. Therefore, after pretesting the survey instrument in Washington, a question was added to ensure that only those actively applying pesticides completed the rest of the questionnaire. Table 1 includes data for three questions that characterize the participants. The number and percentage of responses were included since the number of participants ranged from 102 for Maryland to 1,780 for Iowa. Of the 2,534 individuals who completed the survey, 311 stated that they do not actively apply pesticides and were therefore excluded. Aggregated across all states, 95% of the participants were certified pesticide applicators. The primary pesticide use site varied considerably among the states and included agriculture, landscape maintenance, right-of-way, residential/industrial, and other.

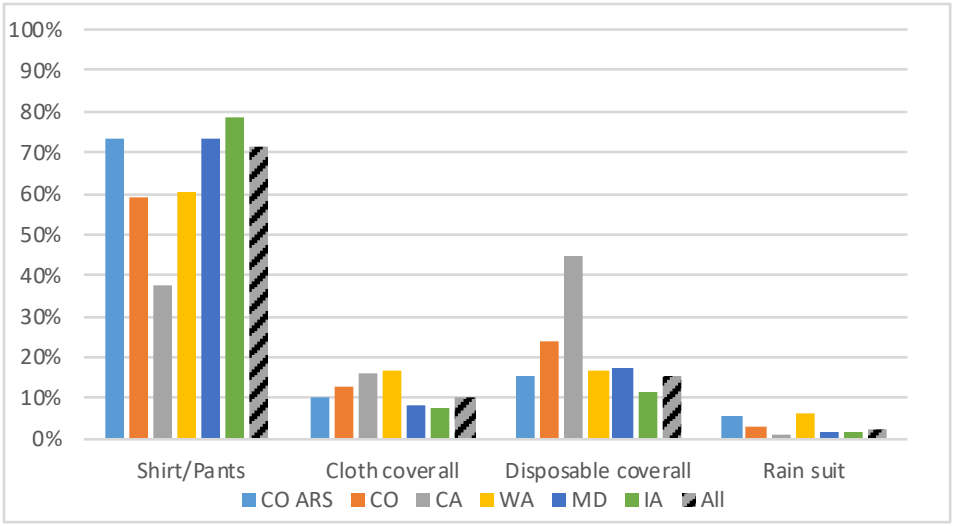
Table 1. Characterization of survey responders.

	California		Colorado		Washington		Maryland		Iowa		All States	
	#	%	#	%	#	%	#	%	#	%	#	%
Question 1. Do you actively apply pesticides?												
No	12	10.0%	7	4.7%	64	16.7%	4	3.9%	224	12.6%	**311**	**12.3%**
Yes	108	90.0%	141	95.3%	320	83.3%	98	96.1%	1,556	87.4%	**2,223**	**87.7%**
Question 2. What type of applicator are you?												
Certified applicator	96	88.1%	135	95.7%	289	90.3%	92	93.9%	1,506	96.7%	**2,118**	**95.1%**
Trained pesticide handler	8	7.3%	2	1.4%	5	1.6%	5	5.1%	51	3.3%	**71**	**3.2%**
Other	5	4.6%	4	2.8%	26	8.1%	1	1.0%	1	0.1%	**37**	**1.7%**
3. What is your primary use of pesticides? (Select one answer)												
Agriculture	57	46.3%	90	64.3%	88	27.4%	55	56.1%	1,097	70.5%	**1,387**	**62.0%**
Landscape maintenance	34	27.6%	18	12.9%	142	44.2%	9	9.2%	247	15.9%	**450**	**20.1%**
Right-of-way	16	13.0%	11	7.9%	58	18.1%	24	24.5%	56	3.6%	**165**	**7.4%**
Residential/Industrial	3	2.4%	16	11.4%	17	5.3%	4	4.1%	141	9.1%	**181**	**8.1%**
Other	13	10.6%	5	3.6%	16	5.0%	6	6.1%	15	1.0%	**55**	**2.5%**

Type of Clothing

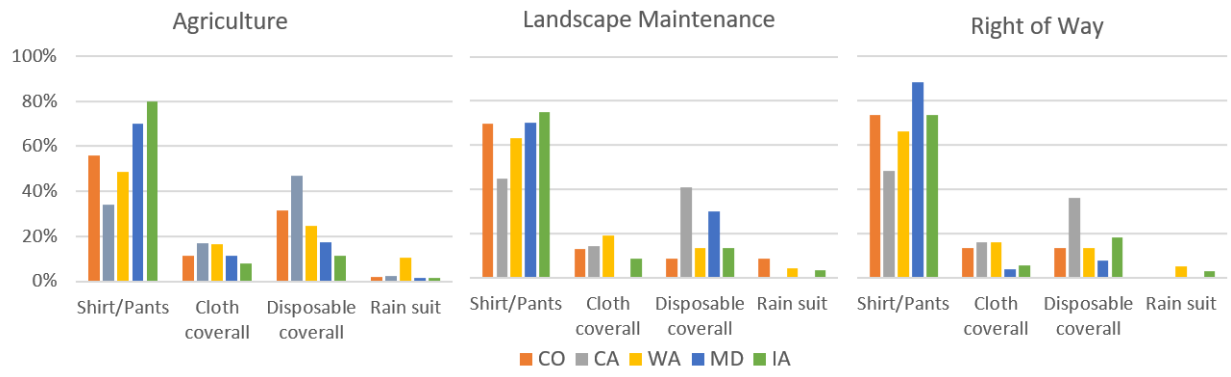
The participants were asked to select clothing commonly worn when applying pesticides. The data for long-sleeved shirt and long pants were grouped as shirt/pants (Fig. 1). Aggregates for all states were 72% shirt/pants, 10% cloth coveralls, 15% disposable coveralls, and 3% rain suits.

Figure 1. Type of garment reported as typically worn when applying pesticides (multiple selections were allowed).



Garment type for each state was also analyzed based on primary use site. Figure 2 includes data for agriculture, landscape maintenance, and right-of-way use sites. In California, for agriculture, 38% selected shirt/pants, 16% cloth coveralls, and 45% disposable coveralls. In Colorado, for agriculture, shirt/pants was the highest category selected (56%) followed by disposable coveralls (31%) as the next highest response. In Washington, the response for shirt/pants was again highest for agriculture. Washington did have the highest response for rain suits (10%) of all the states for agriculture. In Maryland and Iowa, the response for shirt/pants was 70% or higher for all categories.

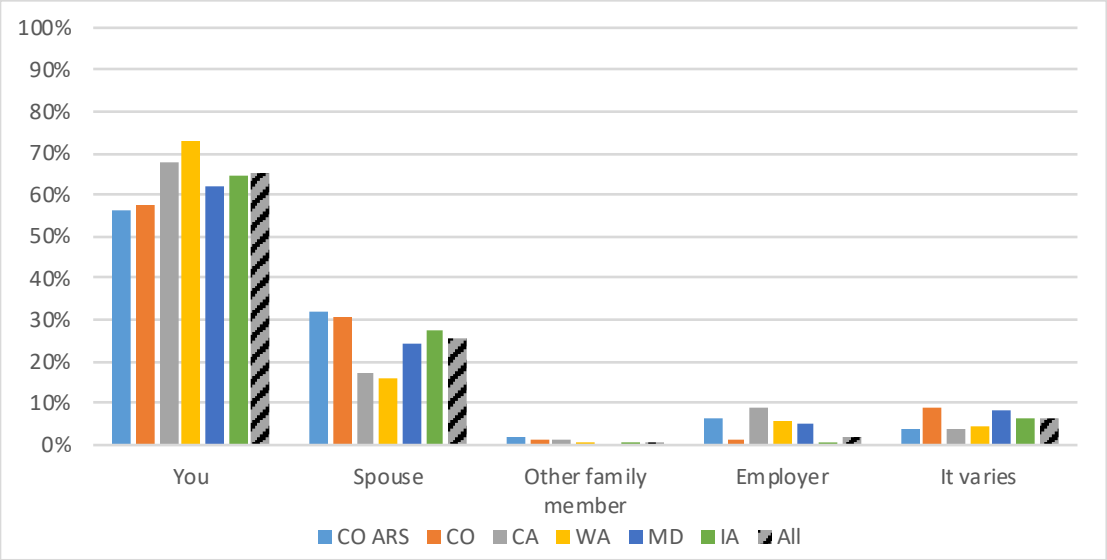
Figure 2. Type of garment reported as worn for agriculture, landscape maintenance, and right-of-way pesticide applications (multiple selections were allowed).



Laundering Practices

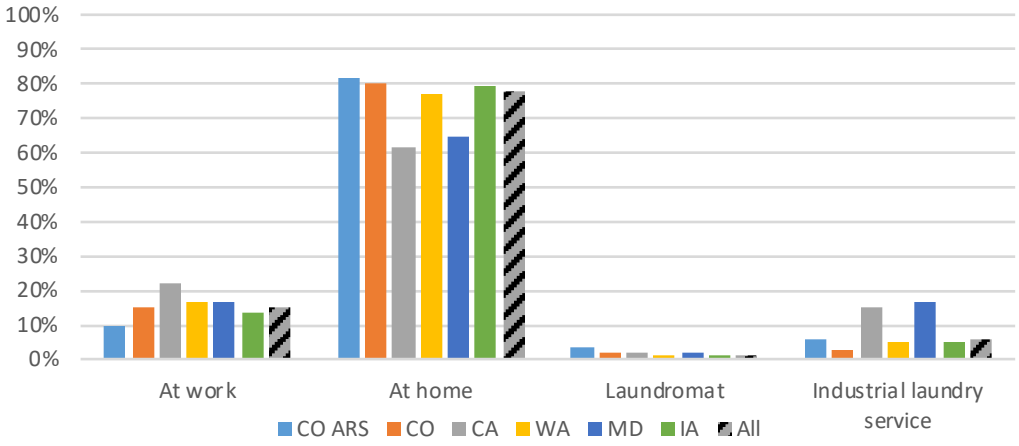
When asked who was responsible for laundering the garments worn while handling pesticides, averaged across all states, 66% of the respondents reported they washed the garments themselves, 26% stated their spouse washed them, 1% selected other, 2% chose employer, and 6% said it varies (Fig. 3). The response for employer included garments cleaned by an industrial laundering service.

Figure 3. Person reported as responsible for washing the pesticide-contaminated garments.



The survey participants were asked to select an option as to where the washable garments (shirt, pants, and cloth coveralls) worn when applying pesticides were most often cleaned. Overall, most of the participants (average of 78% across states) reported garments were most often cleaned at home, 15% at work, 6% in an industrial laundry, and a little over 1% at a laundromat (Fig. 4). As seen in Figure 4, in California and Maryland, a lower percentage selected home (California 62%, Maryland 65%) and a higher percentage selected industrial laundry service (California 15%, Maryland 17%) compared to other states. Compared to the 2000 Nebraska study (Tondl and Schulze, 2000), which had a 95% response for contaminated clothes washed at home, the current percentage of contaminated clothing washed at home in the five states included in the survey is considerably lower. Note that in Maryland, the survey was conducted during just one training workshop, so it may not reflect the typical practice for the entire state.

Figure 4. Locations where washable garments were reported as being cleaned.



Data for laundry practices were also analyzed to assess if there was a relationship between the pesticide use site and where the garments were cleaned. As seen in Table 2, the place where garments were laundered (data from all five states) was similar for agriculture, landscape maintenance, right-of-way, and residential use sites: 10% to 16% selected at work, 75% to 85% home, 1% to 2% laundromat, and 4% to 8% industrial cleaning service. The use site defined as other was slightly different with a higher percentage (24%) reporting garments were laundered at work. Note: Four participants selected at work as well as at home, and one selected at work and industrial. Their responses were counted for both options selected.

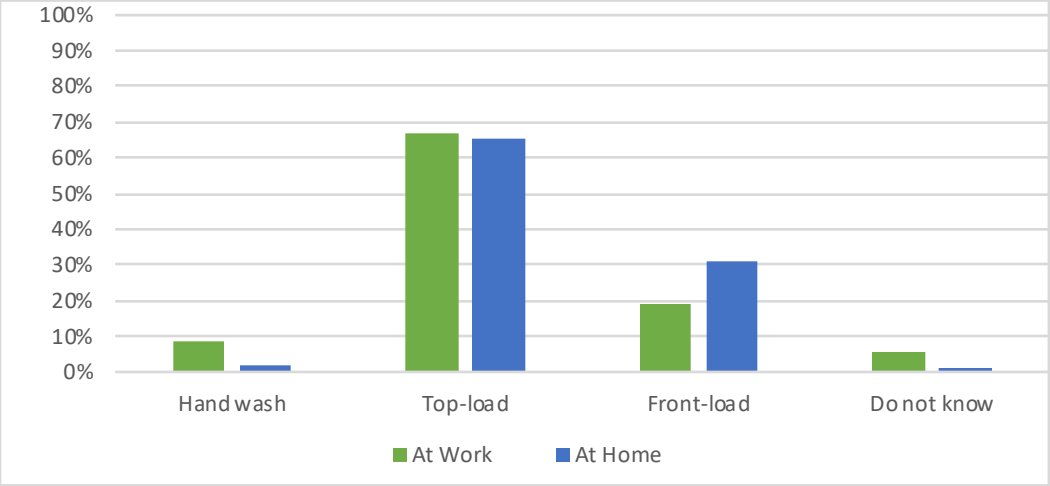
Table 2. Application use site and location where pesticide-contaminated garments were laundered.

	At Work	*At Home*	*Laundromat*	*Industrial*
Agriculture	211 (15%)	1,066 (77%)	15 (1%)	88 (6%)
Landscape maintenance	58 (13%)	347 (78%)	9 (2%)	32 (7%)
Right-of-way	26 (16%)	124 (75%)	2 (1%)	14 (8%)
Residential	18 (10%)	153 (85%)	2 (1%)	8 (4%)
Other	13 (24%)	39 (71%)	3 (5%)	0 (0%)
Total	**326 (15%)**	**1,729 (78%)**	**31 (1%)**	**142 (6%)**

Details provided by respondents for washing and drying practices are reported separately for at work and at home categories. Across all use sites, 78% of respondents selected at home and 15% selected at work as the place where washable garments were most often cleaned. For the at work option, 8% hand washed, 67% used a top-load washer, 19% used a front-load washer, and 6% did not know (Fig. 5). For the at home option, 2% hand washed, 66% used a top-load washer (one selected hand wash and top-load washer), 31% used a front-load washer, and 1% did not know. Data collected in Colorado included a question that divided top-load washers into agitator type and HE type. (All front-load washers are HE.) Data collected from 189 applicators using the paper-based questionnaire showed that nearly the same

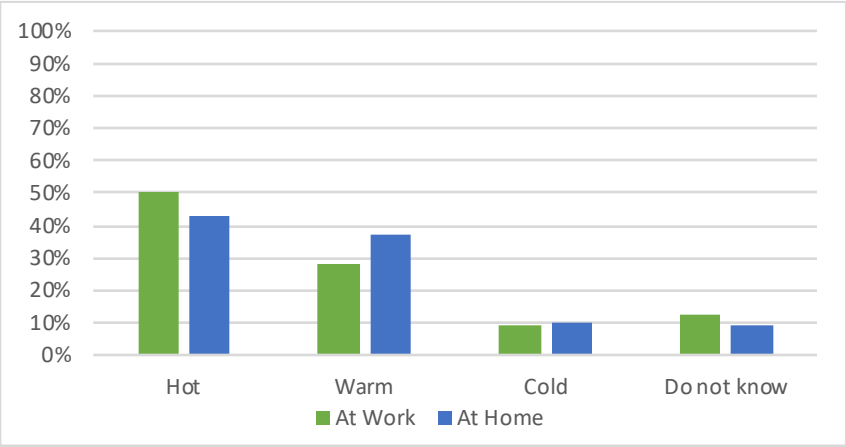
numbers of all three machine types (63 agitator top loaders, 62 HE top loaders, and 64 HE front-loaders) were being used. Data from 474 applicators who provided the information for the three types using ARS showed a higher number selected the agitator type (207) and similar numbers for HE top-load (135) and HE front-load (132) machines. Recognizing machine types would be important for future research studies. Based on the data from Colorado, there is a shift to the newer HE machines.

Figure 5. How pesticide-contaminated garments were reported as being washed.



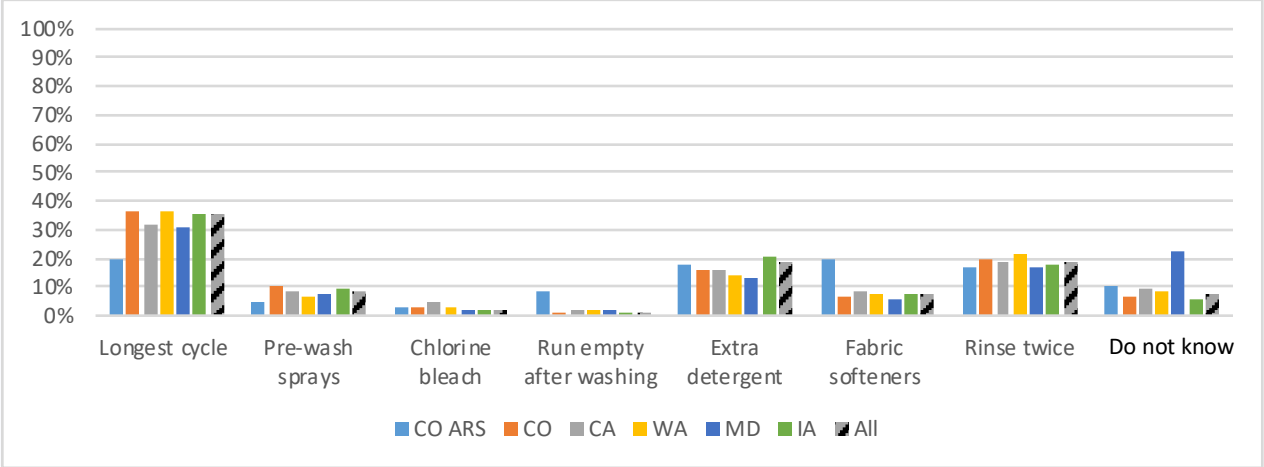
Participants were asked what water temperature was used in automatic washing machines. Of the participants who selected at home, 1,698 responded to this question, and 318 of those who selected at work responded. For garments machine-washed at home, 43% used hot water, 38% warm water, and 10% cold water. The remaining 9% did not know the wash temperature. For garments machine-washed at work, 50% used hot water, 28% warm water, and 9% cold water (Fig. 6). The remaining 12% did not know the wash temperature. In the 2000 Nebraska study for laundry practices, 52% used hot water, 41% warm water, and 6% cold water (Tondl and Schulze, 2000). In both this study and the Nebraska study conducted in 2000, only about half the respondents reported using hot water, which is recommended on the pesticide label as well as in the *National Pesticide Applicator Certification Core Manual* (National Core Manual, 2016).

Figure 6. Wash temperature reported for machine-washing pesticide-contaminated garments.



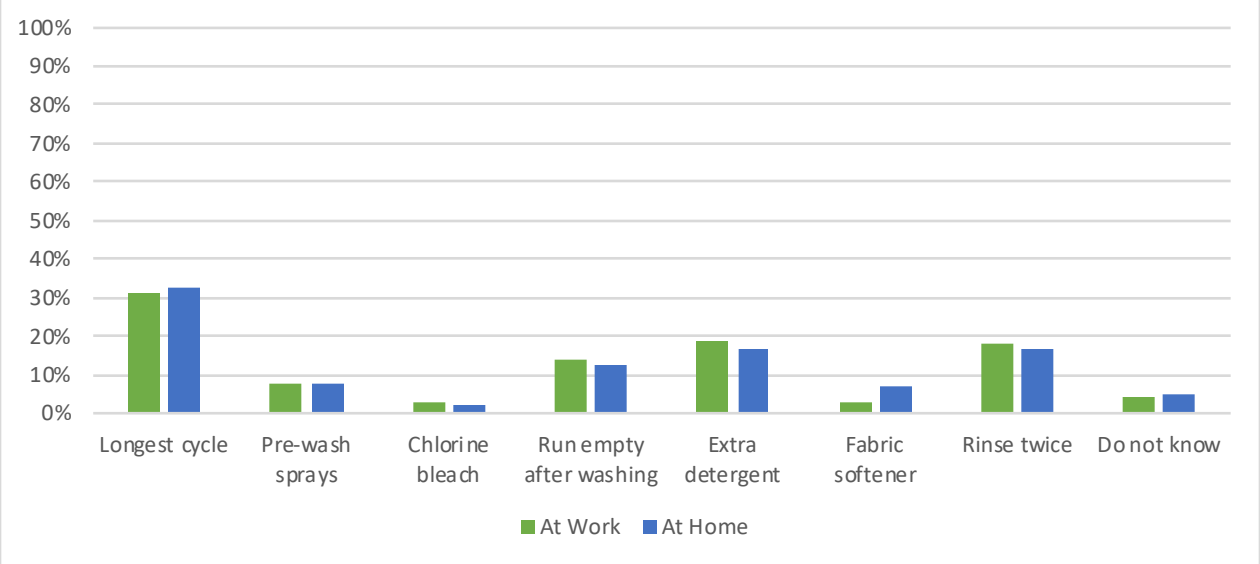
Common precautionary statements on the pesticide label state that PPE should be washed in accordance with manufacturer instructions or in hot water if no instructions are provided. No information is given for laundering ordinary shirts and pants contaminated with pesticides. Many garment labels recommend washing in warm or cold water. However, garment labels are not intended as instructions for laundering pesticide-contaminated clothing. The National Core Manual recommends using hot water, a pre-rinse cycle, heavy-duty detergent, highest water level, longest wash cycle, and line drying if possible (National Core Manual, 2016). Participants in the survey were asked about some of their wash practices (Fig. 7). Using the longest wash cycle was the most common practice. All other options were typically used by fewer than 20% of the respondents.

Figure 7. Wash practices reported when laundering pesticide-contaminated garments.



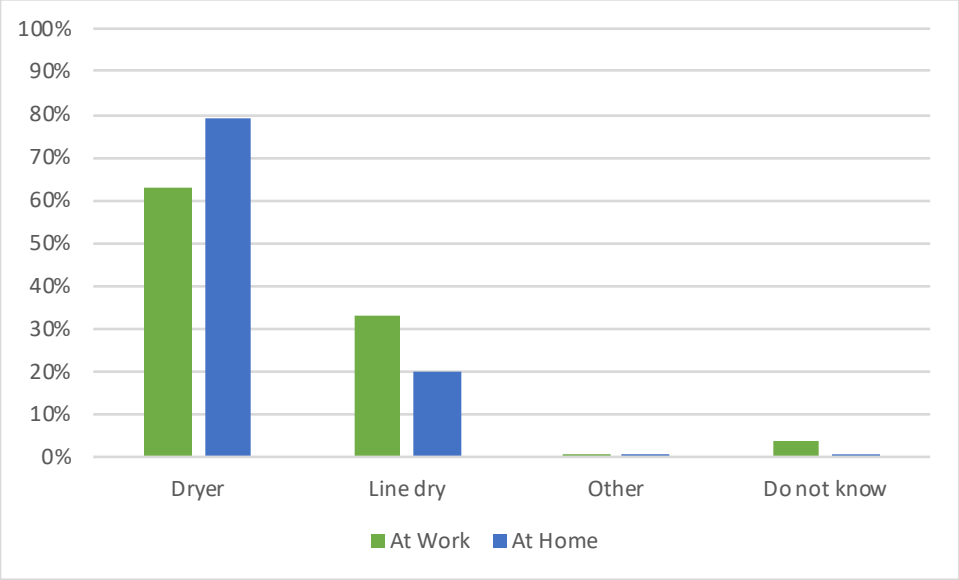
In general, the processes used when laundering pesticide-contaminated clothing were roughly similar when data were compared by state (Fig. 7) and for garments washed at home and at work (Fig. 8).

Figure 8. Wash criteria reported when laundering pesticide-contaminated garments at work and at home.



As seen in Figure 9, a dryer is used for most of the garments washed at home (79%) and at work (63%); line drying had a lower response for at home (20%) and at work (33%). A higher percentage (66%) was reported for line drying in the 2000 Nebraska study (Tondl and Schulze, 2000). Typically, garments are not ironed (95% do not iron, 1% iron, and 4% did not know if the garment was ironed).

Figure 9. Drying method reported for garments washed at work and at home.



Conclusion and Recommendations

The results of the survey show that a long-sleeved shirt and long pants continue to be the most commonly worn garments when applying pesticides. For all applicators, laundering at home was most common, followed by garments washed at work or by industrial services. Additional information is needed on procedures used by industrial laundering services to clean pesticide-contaminated garments. A few applicators use a laundromat to wash contaminated garments, which is a possible health concern.

Both top-load and front-load machines are used at work and at home. Data from Colorado show top-load washers split between agitator type and HE top load. The number of HE machines (top and front load combined) is higher than the older agitator-type machines. Therefore, the authors recommend that future research consider agitator-type washers as well as the two types of high efficiency machines.

With three different types of washing machines and a wide variety of wash settings, detergents, and cleaning aids, the goal of future studies should be to establish the simplest and most effective wash procedure to serve as a baseline. As habits and practices are difficult to change, garment laundering protocol that follows commonly practiced laundering methods by applicators should be included in the study. The degree of cleaning also needs to be determined for different types of formulations and fabric finishes. From this information, an updated laundering guidance document can be prepared. This document could be used to update and improve pesticide applicator training resources (such as factsheets and presentations) for laundering work clothing (pants and shirts) and PPE (cloth coveralls).

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