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Relationships Between Poisoning ...Symptoms Among Iowa Farmers

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Abstract

Clothing worn for farm pesticide application and reports of experience with pesticide poisoning symptoms were studied through a survey using a sample of 1200 private pesticide applicators in Iowa. A 61% return rate was obtained and showed that farm applicators did not vary their clothing according to the toxicity of the chemicals being used. The majority of farm applicators wore jeans, long-sleeved shirts, leather boots, undershorts, socks, and a company/baseball type hat to apply pesticides. Waterproof gloves were worn by 30%. About one-fourth of the farmers said they had never experienced any poisoning symptoms, but 43% had experienced 1 to 4 symptoms and 30% had experienced 5 to 18 symptoms associated with pesticide exposures. Statistically significant relationships were found between the symptom score (number of symptoms experienced) and the toxicity of the insecticide and herbicide that most frequently gets on clothes, the pesticide that gets through clothing to the skin, and the fiber content of the clothes. Symptom score also was significantly related to the age of the applicator and to the number of weeks spent in application each year. Additional research and educational programs are indicated to minimize pesticide exposure.

Clothing is assumed to protect agricultural workers from overexposure to pesticides, but pesticides can be absorbed by, and penetrate through, many clothing fabrics (3, 12). Few specific recommendations concerning clothing have been made by regulatory agencies. Instead, NIOSH and USDA have advised farmers to follow label directions for the specific pesticide they are using (17, 24). Label recommendations vary widely but tend to recommend use of various protective clothing items (1).

Protective clothing was defined in 1974 as "at least a hat or other suitable head covering, a long-sleeved shirt and long-legged trousers or a coverall type garment (all of a closely woven fabric covering the body including arms and legs), shoes and socks (8)." Recommendations were not made about gloves because hearings produced objections by growers, manufacturers, and labor groups who "expressed the view that gloves would increase the hazard by increasing absorption of pesticide residues confined in the gloves (8)." More recently, applicators have been advised by USDA and EPA to wear: 1) a liquid-proof raincoat or apron when handling pesticide concentrates or very toxic materials, 2) trousers outside of boots, 3) unlined neoprene gloves (or those recommended by the label) long enough to cover the wrist with sleeves fitting over them, 4) wide-brimmed waterproof hats, 5) unlined neoprene boots (or follow label instructions), and 6) goggles or face shields (17, 24). Similar recommendations are given by Matthews (16).

The extent of use of protective clothing items by farmers was documented in a study in the north-central region of the United States which asked farm operators in nine states about use of protective gear. The percentages of respondents using various protective items were: respirators 16%, spray suits or other protective clothing 12%, rubber gloves and boots 46%, goggles 24%, and protective tractor cab 23% (25).

Another five-state study evaluated the impact of the private applicator pesticide training and certification programs on use of protective clothing and equipment worn when mixing and loading pesticides that had a skull-and-crossbones symbol on the label. After training, Iowa respondents reported a 32% difference in use of waterproof gloves and a 20% difference in use of goggles or glasses. Reports of differences in use of other protective clothing items after training were less frequent: long-sleeved shirts 8%, dust masks 7%, respirators or filter mask 5%, coveralls 3%, and waterproof boots 2%. These findings were attributed to the fact that in Iowa 95% of the pesticide applications did not require rubber gloves, boots, mask, cartridge respirator, goggles, and rubber coats because applicators were using granular insecticides (23). The report did not make it clear if the differences were increases or decreases in use, but an increase would be expected.

The kind of clothing worn by most Iowa farmers was not reported in either of these studies, and a search of the literature has not identified a study that provided this information. Researchers who have studied the care of pesticide contaminated clothing have assumed that farmers wear work-type clothing. Fabrics selected for laundry research generally have been cotton or polyester/cotton blends in denim, broadcloth, or shirting fabric constructions of various weights and finishes (5, 6, 7, 9, 10, 11, 14).

A survey was conducted in Iowa in March 1984 to learn more about 1) the clothing Iowa farmers wear when applying pesticides and 2) the relationship between clothing worn and farmer's perception of pesticide poisoning symptoms. This report is based on the survey data.

Methodology

A geographically stratified random sample of 1200 registered pesticide applicators in Iowa was drawn by the Iowa Crop and Livestock Reporting Service. The sample number drawn in each county was proportional to the number of registered applicators in the county.

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Each survey participant received a two-part questionnaire with a cover letter by mail. The cover letter asked that the pesticide applicator complete the first part of the questionnaire and that the person in the family responsible for laundering complete the second part. In an attempt to boost return rate, non-respondents were sent a follow-up post card reminder two weeks after the first mailing. A third mailing to non-respondents, sent two weeks after the post card, included a letter and another questionnaire.

The first part of the questionnaire included questions about age, education, household membership, clothing worn, the applicator's experience of poisoning symptoms, attitudes toward pesticide use, and pesticides used. This report summarizes the findings from the applicator's section of the questionnaire. Information about the launderer and laundering procedures were covered in the second part of the questionnaire. The results of the laundry study as well as details concerning methodology and pesticides used most frequently have been reported previously (22).

Applicators were asked to identify which "insecticides" and "other pesticides (herbicide, rodenticide, or fungicide)" — hereinafter referred to as herbicide — were used in greatest quantity in the past two years. Also, they were asked which brand of insecticide or herbicide most frequently gets on clothes. Responses to these questions were coded according to brand label signal words to obtain a toxicity measure.

Applicators were asked to indicate all clothing items usually worn when applying pesticides, protective devices worn, and the fiber content of their clothes. Other questions asked were: how often pesticide gets on clothes, how often it gets through the clothing to the skin, and whether pesticide-soiled clothing is worn again before laundering. Applicators were asked whether they usually changed immediately if they were not wearing waterproof clothing and experienced a "spill of full-strength liquid concentrate" or if "clothes became saturated with spray during application," and how effective they believed the clothes usually worn were in protecting them from pesticide exposure.

Health-related questions concerned the applicator's perception of immediate health risk from using pesticide and its seriousness, and the likelihood of long-term harm and its seriousness.

To study the applicators' perception of experience with illness symptoms associated with pesticide use, 18 different poisoning symptoms pointed out in *Apply Pesticide Correctly* (24) were listed in the questionnaire. Applicators could answer that they had "never, seldom, sometimes, usually, or always" experienced the symptoms.

To investigate the relationship between applicators' reports of poisoning symptoms and clothing, a new "symptom score" variable was created. This variable assigned a value of zero if the symptom was never experienced and a value of one to any reported symptom disregarding the "never" through "always" categories. The 18 symptoms were summed, and applicators who had never experienced symptoms received a symptom score of "0." Applicators who had experienced from one to four symptoms were assigned a symptom score of "1," and those who had experienced five or more symptoms were assigned a symptom score of "2."

Frequencies and percentages were calculated for each variable. The average farm size was calculated from grouped data. A cross-tabulation was considered to exhibit a significant relationship between variables when the probability level for the chi-square test was less than 0.05 (2).

Findings

Questionnaires were returned from all counties in Iowa. In all, 728 questionnaires were returned, providing a 61% return rate. Questionnaires from retired farmers or those no longer farming were excluded. Data analysis included 638 questionnaires. Sample sizes are reported in tables and may be less than 638 because the item did not pertain to every applicator or responses were missing.

Responses were obtained from applicators operating farms of all sizes as shown in Figure 1. The mean farm size

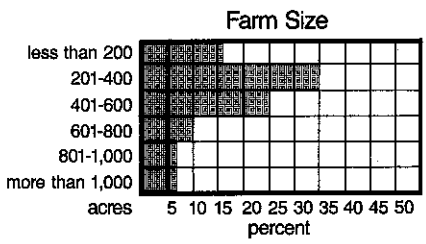

Figure 1

computed from grouped data was 452 acres. According to the Iowa Crop and Livestock Reporting Service, small farm operators are less likely to be registered applicators so that a larger than average farm size was expected for the sample. At the time of the survey the average farm size in Iowa was 297 acres (19).

The percentage of applicators in various age and education categories are shown in Figure 2. Ninety-nine percent of applicators were male and independent farm operators. They ranged in age from 20 to 76 years old.

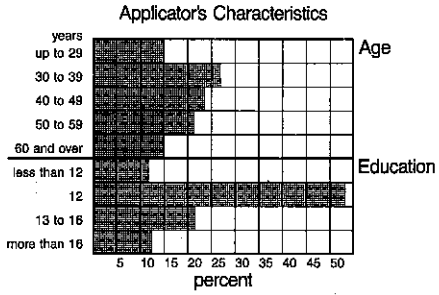

Figure 2

The classes of insecticide most frequently getting on clothes were organophosphates and carbamates. Classes of herbicides most frequently getting on clothes were amide, triazine, dinitroaniline, and thiocarbamate as reported previously (22).

Clothing reported worn most often

At least 59% of Iowa applicators reported that they usually wear long-sleeved work shirts, jeans, undershorts, leather boots, socks, and a company or baseball hat when applying pesticides. Long-sleeved coveralls were worn by 19%. Wearing waterproof gloves was reported by 30%, leather gloves by 23%, canvas gloves by 23%, and 24% did not report wearing gloves. The percent of applicators who said they wear each item are shown in Table 1-A. About 60% of farmers who reported wearing short-sleeved shirts did not report wearing undershirts, sweatshirts, or coats. There were 55 farmers who reported wearing both jeans and coveralls, but this represented only 9% of the total sample. Thirty-eight percent of applicators reported wearing both long-sleeved shirts and undershirts and 48% reported wearing both undershorts and jeans. Sixty-three percent of the farmers said their clothing was usually cotton/polyester blends and 27% said their clothing was usually cotton. About 10% indicated other fibers or did not know what fibers were in their clothes.

The majority (58%) of applicators said they did not wear protective gear. Goggles were worn by 30%, dust masks by 17%, cartridge respirators by 5%,

Table 1
Clothing Worn and Perception of Pesticide Penetration to Skin

A. Percent of applicators reporting wearing each item of clothing (n = 638)		B. Applicator reports of how often pesticide gets through each clothing item to the skin in percent.						
			never	seldom	sometimes	usually	always	don't know
	%	(n)	%	%	%	%	%	%
Coveralls								
longsleeve	19.4	124	25.0	46.0	12.9	4.0	5.6	6.5
jacket or coat	41.8	267	23.6	42.7	14.2	7.1	6.0	6.4
Pants								
bib overalls	11.7	75	20.0	44.0	14.7	5.3	4.0	12.0
jeans	69.1	441	17.9	44.4	18.4	7.7	5.9	5.7
Shirts								
longsleeve	68.2	435	21.8	42.8	17.0	6.7	5.3	6.4
shortsleeve	25.1	160	11.9	46.8	18.1	11.9	5.0	6.3
sweatshirt	35.7	228	16.8	44.7	14.9	11.8	5.7	6.1
Underwear, etc.								
undershirt	45.1	228	18.7	45.5	19.1	4.9	6.6	5.2
undershorts	59.6	380	18.7	43.7	18.9	5.8	6.3	6.6
socks	67.9	433	18.2	45.2	18.5	5.8	5.8	6.5
Leather boots	82.1	524	19.3	43.5	17.9	7.1	5.5	6.7
Gloves								
waterproof	30.1	192	22.9	43.7	16.7	6.3	4.7	5.7
leather	22.5	144	20.1	43.8	15.3	6.9	7.6	6.3
canvas/cotton	23.3	149	20.1	47.7	17.4	8.1	2.0	4.7
Baseball hat	75.5	482	19.3	44.5	18.0	6.6	5.2	6.4

disposable coveralls by 3%, and face shields by 2%.

At least 65% of the applicators indicated that each clothing item listed in Table 1-A gets soiled with pesticide. The data indicate that when pesticide gets on clothing it usually gets through the clothing to the skin (Pearson's r = .64). The proportion of applicators reporting that pesticides get through clothing to their skin more or less often did not differ significantly with the particular clothing items worn (Table 1-B). Regardless of the clothing item, between 12 and 25% said pesticide "never" gets through clothing to the skin, between 43 and 48% indicated "seldom," and between 13 and 19% said "sometimes." Between 2 and 12% said pesticide "usually" or "always" gets through clothing to the skin, and between 5 and 12% responded "don't know."

Applicators reported that liquid formulations of pesticides coming into contact with clothing were significantly more likely to get through clothes to the skin than were granular products as shown in Table 2. About half the most toxic "danger" label pesticide in contact with clothes was granular. Applicators reported that the formulations of insecticide used in greatest quantity in the past two years (n = 638) were 71% granular, 2% powdered, 14% liquid, and 13% other. The formulations of herbicide used in greatest quantity in the past two years were 15% granular, 5% powdered, 66% liquid, and 14% other.

There were no significant relationships between the individual clothing items worn and the level of toxicity of the insecticides or herbicides used in greatest quantity in the past two years. Among farmers who used insecticides and wore jeans, 70% used insecticides labeled "danger," 24% used those labeled "warning," and 6% used those labeled "caution." Among farmers who used herbicides and wore jeans, 24% used herbicides labeled "danger," 45% used those labeled "warning," and 30% used those labeled "caution." A similar percentage of farmers fell into each labeling category regardless of the clothing item worn.

Ten percent of applicators (n = 638) said they wear contaminated clothing again before laundering. Of these, 57 applicators said they wear the clothes two days or less. Although 33% of applicators did not say what they would do if they were not wearing waterproof clothing and had a liquid concentrate spill, of the 426 reporting, 57% said they would change clothes immediately (within an hour). Of the 43% who would not change immediately, 35% said they would change in 1 to 3 hours, 38% said in 4 to 6 hours, and 27% in 7 or more hours. Of the 432 applicators who reported what they would do if they were not wearing waterproof clothing and their clothes became saturated with spray, 63% said they would change immediately. Of the group saying they would not, 49% said they would change in 1 to 3 hours, 27% said in 4 to 6 hours, and the remainder said more than 7 hours.

Poisoning symptom reports and relationships to other variables

Many applicators (27%) did not report any symptoms of pesticide poisoning, but 43% reported 1 to 4 symptoms, and 30% reported 5 to 18 symptoms. Headache, skin irritation, eye irritation, tiredness, and dizziness were the symptoms mentioned most frequently. Table 3-A shows how many farmers reported each symptom. Table 3-B shows how often applicators reporting symptoms said they experienced them. For example, of the 306 applicators reporting skin irritation, 59% said it "seldom" happened. The "sometimes" category includes those who responded "usually" or "always" because there were low frequencies on those categories.

Symptom score (a variable created from the number of symptoms reported by applicators) was significantly related to the toxicity of the brands of insecticides and of the herbicides that most frequently get on clothes. The applicators using more toxic insecticides or herbicides were more likely to report more poisoning symptoms.

Symptom scores were significantly related to the applicators' reports of how often pesticide gets on clothing and how often it gets through clothing to the skin. The more often applicators reported getting pesticides on their clothes or the more often they reported getting pesticide through their clothing to their skin, the more symptoms they reported. Those who wore cotton/polyester blends reported significantly more symptoms than those who wore cotton or other fibers.

Table 2
Perception of Pesticide Penetration

Formulation in contact with clothing (n = 509)		How often pesticide gets through to the skin						
			never	seldom	sometimes	usually	always	don't know
	%	(n)	%	%	%	%	%	%
granular	30.4	155	25.2	47.1	9.0	5.2	.6	12.9
liquid	69.5	354	11.3	46.3	21.2	9.0	8.5	3.7

Table 3
Reports of Experience with Pesticide Poisoning Symptoms

A. Percent of applicators reporting poisoning symptom (n = 638)		B. How often applicators reporting symptoms experienced each		
Symptom	%	(n)	Seldom %	Sometimes %
tiredness	40.4	258	62.4	37.6
headache	54.7	349	47.9	52.1
dizziness	25.2	161	63.4	36.6
eye irritation	44.0	281	54.1	45.9
blurred vision	13.5	86	84.9	15.1
nose bleeds	6.4	41	78.0	22.0
nausea	15.0	96	62.5	37.5
vomiting	3.9	25	80.0	20.0
stomach cramps	9.9	63	76.2	23.8
diarrhea	12.8	82	70.7	29.3
weakness	19.1	122	72.1	27.9
chest discomfort	17.4	111	59.5	40.5
difficulty breathing	16.6	106	67.0	33.0
muscle twitches	12.7	81	79.0	21.0
skin irritation	47.9	306	59.2	40.8
fast heart rate	12.9	82	79.3	20.7
excess sweating	14.9	95	74.7	25.3
fever	10.0	64	76.6	23.4

Applicators who said they "usually did not wear clothes soiled with pesticide again before they were laundered" had a significantly lower symptom score (reported fewer symptoms) than those who wore soiled clothes again.

Significant relationships also were discovered between symptom scores and perceptions about clothing effectiveness and risk associated with pesticide use. Symptom scores were significantly related to the applicator's perception of the effectiveness of clothing as protection from pesticide poisoning. Those who had higher symptom scores were more likely to feel that their clothing was ineffective than those who had lower scores.

Applicators varied in their opinions about whether pesticide on the skin would cause immediate health risk or long-term harm and the seriousness of that risk or harm. If they felt that pesticides would cause immediate health risk, they also were significantly more likely to think that pesticides would cause long-term harm.

Symptom score was significantly related to the age of the applicator and to the number of weeks spent in pesticide application each year. Younger applicators were more likely to report symptoms than older applicators, and those who spent more weeks in application each year were likely to report more symptoms than those who spent fewer weeks. There was no significant relationship found between the total number of years experience with applying pesticides and symptom score.

Discussion

If the 1974 definition from the *Federal Register* is used (8), then most Iowa applicators wear protective clothing. The frequency shown for use of items such as jeans (69%), long-sleeved shirts (68%), and long-sleeved coveralls (19%) suggests that minimal protective clothing is worn by many applicators whether intentional or not. Applicators said the majority of clothing worn was cotton/polyester blends or 100% cotton. These findings show that assumptions made by laundering researchers that work-type clothing is worn by farmers have been correct.

The frequency of experience of poisoning symptoms suggests that the clothing actually worn may not be truly protective and that the definition of protective clothing should be revised. The results of this study do not indicate that Iowa applicators using most-toxic pesticides in greatest quantity (danger label) dress any differently from those using least-toxic pesticides (caution label). It is possible that greater use of protective gear such as coveralls over regular clothing, goggles, masks, or respirators and waterproof boots might decrease the incidence of experience with pesticide poisoning symptoms.

As found in previous research (24, 25), most farmers do not wear protective gear. Farmers use gloves, but less than one-third choose waterproof ones, and 23% choose leather, for which there is no known satisfactory decontamination process. Cotton canvas gloves probably offer least resistance to penetration, but theoretically could at least be partially decontaminated through laundering. Use of unlined rubber gloves is currently recommended but proper decontamination is necessary (13) because gloves that are contaminated on the inside can foster pesticide absorption. Disposable gloves may be an alternative, but disposal is a problem as hazardous waste disposal sites are limited.

The significant relationship between fiber content and symptom score indicates a need for further investigation of the role of fibers and fabric geometry in resistance to penetration and prevention of exposure. If ordinary work-type clothing is to be an effective barrier to penetration, then a way to make cotton or cotton/polyester blend shirts and jeans, as well as leather products, pesticide-resistant and comfortable but, at the same time, easily decontaminated is needed. Some laboratory work on fabric penetration, alternative fabrications, and finishes has been directed toward comparing and understanding performance of fluorochemical finishes, special microfiber-webs, or microporous fabrications (3, 4, 18, 20). Some of the clothes worn by Iowa farmers could have oil- and water-repellent finishes, but such treatments are not typical for shirts and jeans. Further study is needed of the benefit of dual-purpose fluorochemical soil-release finishes in both preventing penetration and easing pesticide removal through laundering. Also, research on the penetration, holding capacity, and decontamination of leather products is needed.

The significant relationship between symptom value and toxicity of the insecticide or herbicide that most frequently gets on clothes seems to verify the importance of the warning labels on pesticides. No specific clothing recommendations are consistently applied to the pesticide warning label classifications (1). Each pesticide manufacturer seems to decide about their labeling recommendations independently. Some labels suggest protective clothing that might be considered by applicators to be overly cautious, impractical, and designed primarily to protect the company from a lawsuit. Clothing recommendations coming from regulatory agencies are general, perhaps because there is an absence of firm evidence of the relationship between protective clothing and poisoning.

Multi-layered clothing outfits may offer greater protection, but the importance of this point is often overlooked, and data

from this study do not indicate that the majority of farmers wear more than two layers (underwear with jeans and shirt). Studies have shown that pesticides do penetrate through closely woven cotton and cotton/polyester blend fabrics of outer clothing (3, 12, 15, 18, 20). In this regard, it should be noted that not all applicators reported wearing jockey/boxer shorts or undershirts. Farmers who do not wear underclothing are failing to take advantage of a layer of protection that could be easily obtained.

Nearly 90% of the applicators said they launder clothing each time it is soiled with pesticide. Educational materials have stressed the importance of this safety point (5, 21, 24). Fewer applicators said they change immediately when their clothing is saturated with spray and even fewer said they change immediately when they have a full-strength liquid concentrate spill. These are situations likely to cause skin exposure that could lead to poisoning. Educational programs need to emphasize not only appropriate clothing, but also appropriate behavior in relation to management of clothes in the case of contamination. Getting out of saturated clothing fast and showering after exposure is important. The questionnaire from this study did not ask if applicators showered immediately after a contamination incident.

Applicators' perceptions of the effectiveness of their clothing as protection were related to their personal experience with poisoning symptoms. Those who believed their clothing was ineffective reported more symptoms. This seems to suggest that clothing provides inadequate protection; but other factors should be examined. It could be that differing attitudes about hygiene and safety precautions are as much to blame for poisoning symptoms as the effectiveness of clothes.

Younger applicators reported higher symptom scores than older applicators, but regardless of age, the more weeks spent in application in one year, the more symptoms applicators experienced. It is expected that a longer exposure time would lead to higher incidence of poisoning symptoms. The lower frequency of perception of poisoning symptoms among the older applicators might be an indication that they have learned to be more careful because of previous experiences, or perhaps they are less well-informed about symptoms of overexposure and do not recognize them as such when they occur.

Applicators who felt that pesticide on the skin would be unlikely to cause an immediate health risk also believed continued exposure would be unlikely to cause long-term harm. Furthermore, if they felt the present risk was mild rather than serious, they also felt the long-term harm would be mild. These attitudes have implications in relation to clothing selection. A person who feels it is very unlikely that pesticide on the skin will cause harm is less likely to select clothing with safety as a consideration. Thus, the people who feel that the risk is less will actually be at greater risk for having failed to dress cautiously. Educational efforts need to focus on developing positive attitudes toward benefit of cautious behavior.

Conclusions

If protective clothing is defined merely as "a hat or other suitable head covering, a long-sleeved shirt and long-legged trousers or a coverall garment, shoes and socks (8)," then Iowa farmers wear protective clothing. With the exception of gloves, few farmers have adopted other protective clothing items such as goggles, respirators, etc. Data from this study indicate there is no relationship between the clothing that is worn and the toxicity of the pesticide that is used.

The clothing that is worn does not prevent the experience of poisoning symptoms. Although over one-fourth of farm applicators reported that they have never experienced any pesticide poisoning symptoms, 43% reported from 1 to 4 symptoms, and 30% reported from 5 to 18 symptoms. Symptoms most often reported were headache, skin and eye irritation, tiredness and dizziness. Symptom score was significantly related to the toxicity of the pesticide used, how often it gets on clothes, how often it gets through clothes to the skin, the fiber content of the clothes, whether pesticide-soiled clothes were laundered before wearing again, the age of the applicator, and the number of weeks spent in application each year, but not to the total number of years experience applying pesticides.

If field studies could demonstrate clearly the benefit of using particular clothing items and protective gear, perhaps farmers might adopt these items. Educational programs in the absence of evidence to support the recommendations may not be sufficient to cause a change in clothing selection behavior, though the findings of this study suggest a strong relationship between the clothing worn for pesticide application and poisoning symptoms.

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