Factors Associated with Safe Use of Agricultural Pesticides in Minnesota

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ABSTRACT: *How farmers protect themselves against pesticide exposure has important public health consequences. To obtain insights into pesticide self-protection, this study obtained data on chemically resistant glove and other protective equipment use as they relate to the type of farming practice, demographic characteristics of farmers and their farming operations, farmers' preventive health beliefs and behaviors, and factors related to their health care. Data were obtained by telephone interviews conducted in six rural Minnesota counties. Survey respondents totaled 1,327 (82% response rate), with 502 reporting pesticide use. Ninety-five percent of the latter respondents believed in the effectiveness of protective equipment and 88 percent believed that pesticide exposures are harmful. Fifty-six percent of the subjects wore chemically resistant gloves and 22 percent wore other protective clothing 75 percent of the time or more when using pesticides. Glove use and certification to use restricted pesticides was less frequent for women. The use of protective equipment in this group of Minnesota farmers was weakly related to being certified to apply restricted pesticides, believing in the effectiveness of protective clothing, believing that smoking causes serious health problems, using crop insecticides, and distance to a health care facility.*

Modern agriculture has become increasingly dependent on the use of pesticides. In the United States more than one billion pounds of pesticides are used each year (Emanuel, 1990). Herbicide use doubled between 1966 and 1980. More than 45,000 products have been registered as pesticides by the Environmental Protection Agency (EPA).

Concern about the relationship between pesticides and disease has accompanied increased pesticide use. Acute intoxication from certain pesticides is a well-established effect of exposure (Blair & Zahm, 1991a; Blair & Zahm, 1991b). Long-term use of specific pesticides has been associated with non-Hodgkin's lymphomas, leukemias, skin cancers, multiple myeloma, and other cancers, although a causal link has not been established (Blair & Zahm, 1991c). Although complete understanding of the relationship of pesticides to cancer is lacking at this

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time, a primary preventive approach to using these chemicals is obviously prudent.

In the United States, safe pesticide use is promoted by a variety of means including legislation, farm machinery engineering, health provider education, and farmer education (Cordes & Rea, 1991). Legislation such as the Federal Insecticide, Fungicide, and Rodenticide Act of 1972 (FIFRA), the Occupational Safety and Health Administration Hazard Communication Standard (1983, for pesticides manufacturers), Worker Protection Standards for Agricultural Pesticides (1974, 1992) and others have had such design. The American Medical Association through its journals and publications has alerted physicians to the hazards of pesticides and has urged proper labeling (Council on Scientific Affairs, 1988).

There are problems, however, with administrative approaches. The typical farming operation in the Midwest, for example, is small, independent, and often isolated from the effects of existing legislation (McJilton & Aherin, 1982). Knowledge of illness in relation to use of pesticides remains largely unknown. The use of phenoxy acid herbicides, for example, may result in exposure despite preventive measures (Kolmodin-Hedman, Hoglund, & Akerblom, 1983). Recent estimates indicate that only 1 percent of farmers with pesticide-related illnesses are reported, limiting the ability to evaluate and implement preventive strategies (Emanuel, 1990).

Education has not been a totally effective means for reducing exposure. In Finland, 50 percent of those involved in an educational intervention continued not to use eye protection. Patterns of other protective equipment use in those involved in educational interventions and those not in these programs were similar (Husman, et al., 1990). The lower utilization of health care, particularly preventive health services, among farming populations could also be related to unsafe pesticide handling practices, if the health care system is a factor (Kralewski, Yuanli, & Shapiro, 1992; Kralewski, Shapiro, & Chan, 1990). More complete understanding of these and other issues may be helpful in designing and implementing effective strategies to enhance safe pesticide use.

This study initiated an intervention in 1992 to gain further insights into preventing health problems in farming populations. The three main areas of the study included breast cancer prevention, skin cancer prevention, and safe handling of pesticides. Countywide intervention programs were designed to enhance the use of preventive strategies for these areas of study. Measurement of the effectiveness of these programs was accomplished by a pre- and postintervention survey. Data for this report were obtained during the pre-intervention phase and provide insights into the target population's pesticide handling practices prior to the intervention.

Methods

Data for the pre-intervention survey were gathered by a computer-assisted telephone interview administered by the Minnesota Agricultural Statistics Service. Farm households were sampled randomly in six Minnesota counties from the list of farm operators maintained by the U.S. Department of Agriculture, Minnesota Agricultural Statistics Service. A farm household was considered eligible if $1,000 or more of agricultural products were produced and sold in a given year. Subjects were selected randomly from farm households in which there was at least one household member aged 40 years or older. This age criterion was selected to maximize participants for the mammogram utilization portion of the study. To ensure a balanced number of subjects by age and gender, an approximately equal number of subjects were sampled from each of six age-gender strata (40 to 54 years, 55 to 64 years, 65 years and older). Survey participants who indicated that they have personally mixed, loaded, or applied pesticides while farming form the group for which this study is based.

The interview consisted of multiple choice, yes/no, and open-ended items. The topics contained within the questionnaire were influenced, in part, by the health belief model (Becker, 1974). Using this model, this study postulated that safe use of pesticides is primarily associated with (1) the farmer's knowledge of the potential severity of disease from pesticide exposure (obtained by questioning them about the harmfulness of long-term pesticide exposure), (2) how susceptible farmers feel toward developing disease following exposure (obtained by questioning them about their concern of getting cancer), and (3) farmers' beliefs in the effectiveness of protective equipment to prevent exposure (obtained by questioning them about their belief in the effectiveness of protective equipment).

Safe pesticide use was also thought of as possibly being associated with farmers' beliefs and behaviors about other preventive health issues. For example, if a farmer practiced other preventive measures (nonsmoker, use of sunscreen, received regular physician exams), this behavior could be related to the use of

protective equipment. Safe pesticide use was also thought of as possibly being associated with health care access and utilization (having health insurance, having a regular provider, distance to provider) because health care providers could serve as a source of knowledge about pesticides and their proper use. The questionnaire was pilot tested prior to use.

Descriptive statistics and univariate analyses using *chi* square tests of significance were conducted. All variables except age were analyzed in a categorical format. Logistic regression analyzing the dependent variables (using chemically resistant gloves and using other protective equipment) and age was conducted separately. Stepwise logistic regression analyses were performed to identify variables that collectively could be used to develop an understanding of protective equipment use. All potential variables were used in the stepwise approach. Age was kept in a continuous variable format. Interaction terms also were assessed for all significant variables in the stepwise regression.

Two dependent variables were used: (1) percent of time farmers use chemically resistant gloves when handling pesticides, and (2) percent of time farmers use other protective clothing (such as respirators, long-sleeve shirts, rubber boots, hats) when handling pesticides. For the analysis, responses to these variables were categorized into 75 percent or more of the time and less than 75 percent of the time. Seventy-five percent was chosen to best represent consistent protective equipment use.

Independent variables in the questionnaire included demographic characteristics, health insurance coverage, health care utilization, risk behaviors, and health beliefs and attitudes.

Results

A total of 1327 individuals (82% of those eligible) responded to the survey. Of these, 502 (38%) reported that they personally mixed, loaded, or applied pesticides. As Table 1 shows, 280 (56%) of the pesticide users wore chemically resistant gloves 75 percent or more of the time. One hundred and eight (22%) wore other protective clothing 75 percent or more of the time. Most of those who reported the use of pesticides were men between the ages of 40 and 54 years. Sixty-one women indicated that they personally mixed, loaded, or applied pesticides. Most of the pesticide users grew corn (84%) and soybeans (82%) and used herbicides (93%) and crop insecticides (59%).

Table 1. Pesticide Applicator and Agricultural Production Characteristics (N=502).

	Number	Percent
Age		
40 to 54 years	58	11.6
55 to 64 years	308	61.4
65 years or older	136	27.1
Gender		
Male	441	86.1
Female	61	13.9
Highest Education Level Attained		
Never graduated from high school	76	15.1
High school graduate	234	46.6
Post secondary education	192	38.2
Marital Status		
Married or living as married	432	86.0
Not married	70	14.0
Income		
Less than $35,000	285	56.8
$35,000 or more	180	35.9
Refused/Unknown	37	7.4
Amount of Land in Production		
0 to 399 acres	263	52.7
400 or more acres	236	47.3
Grow Corn	422	84.1
Grow Soybeans	410	81.7
Types of Pesticide Used		
Livestock insecticides	191	37.0
Crop insecticides	296	59.0
Herbicides	467	93.0
Fungicides	61	12.2
Percent of Time Using Chemically Resistant Gloves		
0 to 74 percent	222	44.2
75 to 100 percent	280	55.8
Percent of Time Using Other Protective Clothing		
0 to 74 percent	394	78.5
75 to 100 percent	108	21.5
Pesticide Applicator Certification Status		
Currently certified	364	72.5
Not currently certified	138	27.5

Table 2. Chemically Resistant Glove and Other Protective Clothing Use by Pesticide Applicator and Agricultural Production Characteristics.

		Chemically Resistant Glove Use		Other Protective Clothing Use	
		Less Than 75 Percent of the Time	75 Percent or More of the Time	Less Than 75 Percent of the Time	75 Percent or More of the Time
	Number	Percent	Percent	Percent	Percent
Age					
40 to 54 years	308	42.2	57.8	79.5	20.5
55 to 64 years	136	51.5	48.5	76.5	23.5
65 years or older	58	37.9	62.1	77.6	22.4
Gender					
Male	441	42.6	57.4	79.1	10.9
Female	61	55.7	44.3	73.8	26.2
Marital Status					
Married	432	43.5	56.5	80.0	20.0
Not married	70	48.6	51.4	78.2	21.8
Employed for Wages					
Yes	404	41.8	58.2	70.4	29.6*
No	98	44.8	55.2	80.4	19.6
Retired					
Yes	18	66.7	33.3	83.3	16.7
No	484	43.4	56.6	78.3	21.7
Income					
Less than $35,000	285	43.5	56.5	80.7	19.3
$35,000 or more	180	45.6	54.4	75.6	24.4
Unknown/refused	37	43.2	56.8	75.7	24.3
Education					
Less than high school	76	51.3	48.7	76.3	23.7
High school	234	44.0	56.0	78.6	21.4
Post secondary school	192	41.7	58.3	79.2	20.8
Health Insurance					
Yes	473	43.6	56.4	78.2	17.2
No	29	55.2	44.8	82.8	21.8
Distance to Routine Health Care					
20 miles or fewer	383	41.3	58.7†	79.6	20.4
More than 20 miles	119	53.8	46.2	74.8	25.2
Time Since Last Routine Check Up					
18 months or fewer	326	42.3	57.7	77.9	22.1
More than 18 months	176	47.7	52.3	79.5	20.5

(Table 2 continued on facing page.)

Table 2 (continued)

		Chemically Resistant Glove Use		Other Protective Clothing Use	
		Less Than 75 Percent of the Time	75 Percent or More of the Time	Less Than 75 Percent of the Time	75 Percent or More of the Time
	Number	Percent	Percent	Percent	Percent
Land in Production					
Fewer than 400 acres	263	44.9	55.1	79.1	20.9
400 acres or more	236	43.2	56.8	77.5	22.5
Grow Corn					
Yes	422	43.1	56.9	79.4	20.6
No	80	50.0	50.0	73.8	26.3
Grow Soybeans					
Yes	410	42.7	57.3	79.8	20.2
No	92	51.5	48.9	72.8	27.2
Raise Livestock					
Yes	473	43.3	56.7	78.6	21.4
No	29	58.6	41.4	75.9	24.1
Use Livestock Insecticides					
Yes	191	41.9	58.1	78.0	22.0
No	311	45.7	54.3	78.8	21.2
Use Crop Insecticides					
Yes	296	39.9	60.1*	75.7	24.3
No	206	50.5	49.5	82.5	17.5
Use Herbicides					
Yes	467	43.0	57.0	78.6	21.4
No	35	60.0	40.0	77.1	22.9
Use Fungicides					
Yes	61	44.3	55.7	82.0	18.0
No	441	44.2	55.8	78.0	22.0

† *Chi* square $P<0.01$
• *Chi* square $P<0.05$

Table 2 shows the relationship of using chemically resistant gloves and other protective clothing to pesticide user characteristics, using *chi*-square analyses. Although not statistically significant, women were less likely than men to report using chemically resistant gloves (44% versus 57%), but were more likely to report using protective clothing (26% versus 21%). Distance to routine health care and use of herbicides were both significantly related to wearing gloves 75 percent or more of the time. By separate logistic regression analyses, there were no associations between glove or other protective clothing use and age.

Table 3 describes the use of chemically resistant gloves and other protective clothing by beliefs and practices about pesticide exposures. Most respondents believed that long-term exposure to pesticides is very or somewhat harmful (88%) and that protective clothing is very or somewhat effective in pre-

Table 3. Chemically Resistant Glove and Other Protective Clothing Use by Pesticide Exposure Beliefs and Practices.

		Chemically Resistant Glove Use		Other Protective Clothing Use	
		Less Than 75 Percent of the Time	75 Percent or More of the Time	Less Than 75 Percent of the Time	75 Percent or More of the Time
	Number	Percent	Percent	Percent	Percent
Perceived Harmfulness of Exposure to Pesticides					
Very	270	45.2	54.8	74.4	25.6*
Somewhat	171	43.9	56.1	81.3	18.7
Not at all/unknown	61	41.0	59.0	88.5	11.5
Effectiveness of Protective Clothing in Preventing Pesticide Exposure					
Very/somewhat	477	43.0	57.0*	77.6	22.4
Not effective/not sure	25	68.0	32.0	96.0	4.0
Pesticide Applicator Certification Status					
Currently certified	364	39.6	60.4†	77.7	22.3
Not currently certified	138	56.5	43.5	80.4	19.6
Source for Most Pesticide Information					
Health professionals	9	55.6	44.4	88.9	11.1
Agricultural educators/professionals	306	41.2	58.8	77.5	22.5
Media/product labels	174	50.6	49.4	79.9	20.1
Other/unknown	13	23.1	76.9	76.9	23.1
Percent of Time Using Chemically Resistant Gloves					
0 to 74 percent	222	—	—	90.1	9.9†
75 to 100 percent	280	—	—	69.3	30.7
Percent of Time Using Protective Clothing					
0 to 74 percent	108	50.8	49.2†	—	—
75 to 100 percent	394	20.4	79.6	—	—

† *Chi* square $P<0.01$
* *Chi* square $P<0.05$

venting exposure (95%). The perception that exposure to pesticides is harmful and that protective clothing is effective in preventing exposure were associated with higher levels of both chemically resistant glove and other protective clothing use. Current pesticide applicator certification was related to using chemically resistant gloves but not to other protective clothing. Eighty-one percent of the men were certified to apply restricted use pesticides versus 8 percent of women.

The relationship between consistent use of chemically resistant gloves and other protective clothing with other preventive health beliefs and practices is shown in Table 4. Few preventive health beliefs or practices are related to glove or other protective clothing use. Farmers who believe that serious health problems result from smoking were more likely to use gloves and other protective clothing.

The results of an age-controlled stepwise logistic regression revealed six variables that were associated with using chemically resistant gloves. These were being certified to apply restricted use pesticides

Table 4. Chemically Resistant Glove and Other Protective Clothing Use by Other Preventive Health Beliefs and Practices.

		Chemically Resistant Glove Use		Other Protective Clothing Use	
		Less Than 75 Percent of the Time	75 Percent or More of the Time	Less Than 75 Percent of the Time	75 Percent or More of the Time
	Number	Percent	Percent	Percent	Percent
Current Smoker					
Yes	78	43.6	56.4	75.6	24.4
No	424	44.3	55.7	79.0	21.0
Likelihood of Serious Health Problems from Smoking					
Very likely	343	39.7	60.3†	75.8	24.2*
Not likely	159	54.1	45.9	84.3	15.7
Believe that Long-term Sun Exposure is Harmful					
Yes	438	43.4	56.6	77.6	22.4
No/not sure	64	50.0	50.0	84.4	15.6
Usually Wear Protective Clothing When Outdoors					
Yes	359	42.3	57.7	78.0	22.0
No	143	49.0	51.0	79.7	20.3
Usually Use Sunscreen When Outdoors					
Yes	85	40.0	60.0	74.1	25.9
No	417	45.1	54.9	79.4	20.6
Chance of Surviving Skin Cancer with Early Detection and Treatment					
Good	442	43.7	56.3	79.6	20.4
Fair	29	41.4	58.6	65.5	34.5
Poor	31	54.8	45.2	74.2	25.8
Which Causes More Cancer Cases?					
Personal behaviors	117	51.3	48.7	79.5	20.5
Environmental/genetic factors	180	46.1	53.9	80.6	19.4
Both/not sure	205	38.5	61.5	76.1	23.9
How Concerned About Getting Cancer					
Very	101	43.6	56.4	72.3	27.7
Somewhat	333	42.6	57.4	79.0	21.0
Not at all	68	52.9	47.1	85.3	14.7

† *Chi* square $P<0.01$
* *Chi* square $P<0.05$

(OR=2.0, CI=1.4, 3.1), belief in the effectiveness of protective clothing (OR=2.0, CI=1.2, 7.4), belief in smoking as a serious cause of health problems (OR=1.9, CI=1.2, 2.8), use of crop insecticides (OR=1.6, CI=1.1, 2.3), distance to health care facility less than 20 miles (OR=1.6, CI=1.0, 2.5), and belief in environmental causes as being more important in cancer causation (OR=1.6, CI=1.0, 3.3). No interaction

terms were significant. These six variables explained only 5 percent of the variance in using chemically resistant gloves.

The results of a stepwise logistic regression analysis, again controlled for age, revealed only one variable associated with using other protective clothing. This was the belief in pesticides being harmful to health (OR=2.7, CI=1.2, 6.1).

Discussion

The issue of safe use of pesticides has important public health implications for farmers. Studies assessing farmers' pesticide handling practices point to the need to improve the use of protective equipment and techniques as well as the need to enhance the understanding of potential health problems related to their use (Abrams, Hogan, & Maibach, 1991; Branson & Sweeney, 1991; Fenske, 1990; Fenske, Blacker, Hamburger, & Simon, 1990; Goldsmith, 1989; Helmers, Dykstra, & Kemp, 1990; Kurtz, Shaw, Kelter, & Jackson, 1987; Moses, 1989; Osorio, Ames, Rosenberg, & Mengle, 1991). Other than administrative efforts, there has not been a uniform approach developed to enhance safe pesticide use, nor has there been much understanding of how this can be done effectively.

The study's data indicate that farmers who use pesticides are aware of the risks associated with pesticide exposure and believe that protective equipment is effective in preventing exposure but, disproportionately, do not act on these beliefs. The reason for this discrepancy remains unknown, but may be related to factors such as lack of insight into the effects of long-term chemical exposures, lack of perceived susceptibility to disease, influences of local culture on pesticide use, and learning patterns about pesticides during earlier periods.

The questionnaire used in this study did not contain information that could be used to measure all aspects of safe pesticide handling. Factors such as family pressures to use protective equipment and community standards as they relate to farming practices, were felt to be too difficult or too lengthy to assess. Comfort, availability, and cost of protective equipment were not directly measured, but, in the case of cost as a potential barrier, indirect insight was obtained by assessing income as it related to safe pesticide handling.

None of the independent variables (farming characteristics, demographic characteristics of farmers, their preventive health beliefs and practices, and factors associated with their health care) were strongly associated with safe pesticide handling practices. There were weak associations with two farming variables (being certified to apply restricted use pesticides and use of crop insecticides), three health beliefs (believing that smoking can cause serious health problems, believing in the effectiveness of protective clothing, believing that environmental or genetic factors cause more cancer), and having a distance to routine health care of fewer than 20 miles. Being certified to apply restricted use pesticides was related to chemically resistant glove use, which appears to indicate some degree of effectiveness relative to the required training that accompanies this certification process.

This study was unable to identify the reasons for the relationship between the use of chemically resistant gloves and use of crop insecticides. Possible explanations include the high proportion of "restricted use" pesticides in this category (which require farmers to be certified before they can apply them) or to the known acute toxicity of insecticides.

Access to health care, other than distance to a routine health care provider, was not related to safe pesticide use in this group of farmers. Health insurance coverage and having had recent routine examinations were not related to safe pesticide use. However, only nine of the 502 individuals in the study indicated that they received information about safe pesticide handling from their health care providers. The effectiveness of health care organizations in changing preventive health behavior among populations has been demonstrated and may be a better way of approaching the problem than addressing the safe pesticide use issue to individual farmers (Kleinman, 1980). Because more than 90 percent of those surveyed indicated that they have a regular source of health care, there is significant potential for the health care system to improve farmers' pesticide handling practices.

Women were considerably less likely to be certified pesticide applicators. Women in the United States and elsewhere have a substantial involvement in farming (Kralewski, et al., 1992). Concerns regarding disease relationships among women farmers have appeared in several studies (Brownson, Alavanja, & Chang, 1993; Dewailly, et al., 1994; McDuffie, 1994; McDuffie, Towstego, & Pahwa, 1994; Olsen, 1988; Silverman, McLaughlin, Malker, Weiner, & Ericson, 1989; Stubbs, Harris, & Spear, 1984; Vineis, et al., 1987; Zahm, et al., 1993). Several of these relate pesticide exposure as a possible explanation. In view of the fact

that only 8 percent of women in this study are currently certified, they are a group on which to focus preventive exposure efforts.

This study has several limitations. Because the survey was administered only to household members aged 40 years or older, the results can not be generalized to younger farmers. Secondly, protective equipment use was self-reported and could not be validated. Additionally, assessment of the use of chemically resistant gloves and other protective clothing may not be the best way to measure safe pesticide use. However, there are data that indicate that in North American farmers, gloves are the major method of protection (Branson & Sweeney, 1991), which is consistent with this study's results. This and the fact that most pesticide exposures in agricultural and industrial settings are thought to occur through the skin would seem to suggest that these end points are reasonable to use in estimating safe pesticide use (Abrams, et al., 1991). There may also be difficulty generalizing this information to other parts of the country because the types of pesticides used varies geographically and pesticide handling practices may vary accordingly.

In summary, the use of safe pesticide handling practices by Minnesota farmers appeared to be less than optimum, even though farmers believe that exposure to pesticides was potentially harmful and that chemically resistant gloves and other protective clothing were effective in preventing exposure. Being certified to apply restricted use pesticides, believing in the effectiveness of protective clothing, believing in smoking as a serious cause of health problems, use of crop insecticides and distance to a health care facility of less than 20 miles were weakly associated with the use of chemically resistant gloves. Further insights into the safe use of pesticides may be enhanced by more understanding of these variables. In addition, targeting groups that underutilize protective equipment, examining the health care system as a means to educate farmers and greater understanding of the discrepancy between preventive beliefs and preventive practice among farmers would seem to be worthy areas of study.

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