Association of Pesticide Safety Knowledge With Beliefs and Intentions Among Farm Pesticide Applicators

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Although a number of health hazards associated with pesticide exposure have been well documented, relatively little is known about the knowledge and health beliefs that may influence pesticide handling. This study measured knowledge levels concerning pesticide safety and precautionary handling among applicators and examined relationships between knowledge scores and intentions to use handling precautions, perceptions of pesticide safety peer norms, and perceived self-efficacy to prevent personal exposure. Telephone interviews were conducted with a randomly selected sample of 164 dairy farmers who were pesticide applicators residing in Wisconsin (response rate = 77.4%). The percentage of correct responses to 18 knowledge items ranged from 100% to 45.7%. Knowledge levels were positively related to intentions, beliefs, and self-efficacy regarding use of personal protective gear but were not significantly related to risk perceptions and peer norms concerning pesticide safety.

Evidence of the association between agrichemical exposure and specific cancers continues to emerge. Since 1990, more than 30 studies investigating cancer among farmers have been published in peer-reviewed journals.[1-7] Relatively little is known about the actual handling and personal protective equipment practices of applicators that can lead to exposure or about the knowledge and health beliefs that may influence pesticide use behaviors. Absorption through the skin is considered to be the most frequent means of pesticide exposure, although pesticides can also enter the body through inhalation or ingestion.[8] Although some agents require the use of a respirator during mixing, loading, and application, most substances have a minimum requirement of wearing chemical resistant gloves and boots during handling. Washing hands and other exposed skin areas and changing pesticide soiled clothes immediately after application are also recommended.

In accordance with Environmental Protection Agency guidelines, each state administers a training and certification program that limits the use of restricted pesticides to individuals who successfully complete a certification course and written examination.[9] According to certification definitions, private applicators apply only to land they or their employers own, whereas commercial applicators work for private companies that hire out their services to individuals and other companies. Both private

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and commercial applicators apply pesticides in both farm and other agricultural settings and in private homes, lawns, and gardens. The sale of all restricted pesticides is documented and monitored by each state. The effectiveness of the certification programs and sales monitoring in preventing environmental contamination is evaluated in many states through periodic tests of groundwater and wells. No follow-up occurs regarding the safe handling practices taught during certification. Recertification is issued to private and commercial applicators through completion of continuing education credits or through written reexamination on schedules that vary by state. Because periodic monitoring or site visits to application environments remain infeasible, responsibility for safe handling is left to the applicator.

This study sought to: (1) identify levels of knowledge concerning pesticide safety and precautionary handling, and (2) examine the relationship between knowledge scores and intentions to use handling precautions, perceptions of pesticide safety peer norms, and perceived self-efficacy to prevent personal exposure as reported by certified private applicators.

Methods

Telephone interviews were conducted with a randomly selected sample of dairy farmers who were pesticide applicators residing in Wisconsin. A random number generator[10] was used to select a simple random sample of pesticide applicators working on dairy farms in Wisconsin. Eligibility criteria for interview were: (1) being a dairy farmer (milked cows at least once in the prior year), and (2) current certification to apply restricted use pesticides. Final status codes were completed for 205 applicators; 6 applicators had incorrect contact information and 12 could not be reached after 10 attempts over a 2-week period. A total of 164 individuals were eligible to participate in the interview; 127 completed the interview and 37 refused. The overall interview response rate was 77.4%.

Trained interviewers administered a 20-minute structured interview to each selected respondent. The interview included demographic and psychosocial risk assessment items.

Demographic items were respondent age, level of education, total farm and non-farm incomes, farm acreage, and total types of livestock currently raised on the farm.

Psychosocial risk assessment items were constructed to measure pesticide safety knowledge, intentions, beliefs, risk perceptions, peer norms, and self-efficacy (Tables 1 through 6 include item wording). Items specific to pesticide handling and safety were constructed using question structures used in prior investigations of health behaviors, including cigarette smoking, breast self-examination, and condom use.[11–18]

Knowledge items were based on information included in the Wisconsin Pesticide Application Training Manual.[19] Eighteen true/false pesticide safety and risk items were used to construct the knowledge scale. The items included questions about safety information sources, proper protective equipment use, and the health effects of pesticide exposure.

Six behavioral intention items were asked the applicators concerning their intentions to follow precautions the next time they used a pesticide. The response option ranged on a 4-point scale, from 1 = strongly disagree to 4 = strongly agree.

Four safety belief items were asked concerning applicators' beliefs about pesticide hazards. The response option ranged on a 4-point scale, from 1 = strongly disagree to 4 = strongly agree.

Three risk perception items measured applicators' perceived risk of hazards associated with exposure. The response option ranged on a scale of 0 = very unlikely to 10 = very likely.

Five peer norm items measured applicators' perceptions of pesticide safety among other farmers they know. The response option ranged on a 4-point scale, from 1 = strongly disagree to 4 = strongly agree.

Six self-efficacy items concerned applicators' confidence to avoid exposure and to use the required protective equipment during application. The response option ranged on a scale of 0 = not at all confident to 10 = very confident.

Statistical Methods

Knowledge scale performance was assessed by using Cronbach's alphas to measure item internal consistency and inter-item agreement. To examine the relationship between knowledge scale scores and the individual psychosocial risk assessment items, both Spearman rank correlation coefficients as well as odds ratios with their 95% confidence intervals were calculated.[20] The Spearman rank correlation coefficients were calculated by using the continuous variables: the total number of knowledge questions answered correctly; the 4-point scales for intentions, beliefs, and norms; and the 10-point scales for risk perceptions and self-efficacy. To calculate the odds ratios, dichotomous variables were used. Knowledge scores were dichotomized by using a median cut of the distribution into 14 or fewer items correct and 15 or more items correct. Intentions, beliefs, and peer norm scores were dichotomized into agree and disagree categories. Risk perception ratings were separated into three categories based on tertiles: 0–3 likelihood, 4–6 likelihood, and 7–10 likelihood. Self-efficacy ratings were dichotomized using a median cut into categories: 0–7 confidence rating and 8–10 confidence rating. Calculations were performed by using the SAS statistical package.[21]

Results

Ninety-nine percent (126) of the sample farmers were male; mean age was 44 (range, 28 to 81); the mean

TABLE 1
Pesticide Safety Knowledge Items and Scale Performance Among Private Dairy Applicators (n = 127)

Knowledge Item (Correct Response)*	No. Correct	%	Cronbach Coefficient (α)	Correlation With Total
1. The most important information source is the label. (true)	121	95.3	0.363	0.048
2. Chemical resistant coveralls are the only protection you need. (false)	121	95.3	0.357	0.089
3. If you smell a pesticide odor, the cartridge should be replaced. (true)	97	76.4	0.364	0.069
4. Any respirator will be effective for all types of pesticides. (false)	103	81.1	0.320	0.207
5. Wash your gloves and boots with detergent and water. (true)	98	77.2	0.335	0.157
6. When transporting pesticides, you don't need protective clothing. (false)	61	48.0	0.369	0.068
7. The pesticide concentrate is the chemical is in its most toxic form. (true)	111	87.4	0.340	0.150
8. Some pesticides have been shown to cause cancer in animals. (true)	97	76.4	0.361	0.080
9. Some cancer rates are higher among farmers than others. (true)	71	55.9	0.378	0.043
10. Inhaling pesticides is the most common form of exposure. (false)	58	45.7	0.424	−0.083
11. Clothes worn with pesticides can be washed with other clothes. (false)	125	98.5	0.345	0.244
12. Leather is the best material for protective gloves. (false)	121	95.3	0.343	0.171
13. Never wear hats of cotton, felt, straw, or leather in application. (true)	80	63.0	0.317	0.198
14. A dust mask is an effective substitute for a pesticide respirator. (false)	118	92.9	0.332	0.210
15. Drying clothes from application on line is preferable to dryer. (true)	97	76.4	0.339	0.144
16. There are no physical symptoms with pesticide poisoning. (false)	114	89.8	0.321	0.235
17. Must wash immediately after pesticides in contact with skin. (true)	124	97.6	0.347	0.187
18. Have a supply of water available when working with pesticide. (true)	127	100.0	0.366	
Cronbach coefficient α for all 18 knowledge items			0.364	

* Performance on knowledge items: Range, 9–18 total correct; mean, 14.5 correct; median, 15 correct.

number of children in the household was 1.5 (range, 0 to 4). The mean gross farm income (income originating from farm activities) in 1995 was $152,050 (range, $3500 to $500,000); mean number of acres farmed in 1995 was 333.8 (range, 1 to 1200); mean number of milk cows was 64.1 (range, 0 to 200); and 91.3% reported milking cows daily.

Table 1 lists the 18 knowledge items; the percentage of the participants who scored each item correctly; the alpha values for each item; and the range, mean, median, and total alpha of the scale. Percent correct ranged from 100% for the item "You should always have a supply of clean water available when working with a pesticide (true)" to 45.7% for the item "Inhaling pesticides is the most common exposure among applicators (false)." Cronbach's alpha coefficient for the overall scale was 0.365, ranging from 0.317 to 0.424 with the exclusion of individual items. Eight of the 18 items had correct scores of less than 80%, and four items had correct scores of less than 70%.

Table 2 presents odds ratios, 95% confidence intervals, and correlation coefficients for knowledge scores by applicators' intentions to use personal protective equipment. Knowledge scores were significantly associated with intentions to get pesticide safety information (Spearman Rank P = 0.004) and to have a clean supply of water available the next time the applicators used pesticides (Spearman Rank P = 0.037). Individuals scoring higher in knowledge were more likely to report the intention to get information and to have water available. Knowledge scores were not significantly associated with intentions to wait for favorable weather conditions, to wear a chemical resistant suit, or to wear a respirator the next time pesticides were used.

Table 3 presents odds ratios, 95% confidence intervals, and correlation coefficients for knowledge scores by beliefs regarding hazards and use of personal protective equipment. Knowledge scores were inversely associated with being too busy to use protective equipment (Spearman Rank P = 0.009) and with the belief that exposure to pesticides will not cause cancer (Spearman Rank P = 0.013). Individuals scoring higher in knowledge were less likely to report being too busy and were more likely to disagree with the statement that pesticide exposure does not cause cancer. Knowledge scores were not significantly associated with the beliefs that direct exposure is not harmful to human health and that a pesticide would not be put on the market if it weren't safe for humans to use.

Table 4 presents odds ratios, 95% confidence intervals, and correlation coefficients for knowledge scores by applicators' perception of pesticide risks. Knowledge scores were not significantly associated with perceptions of immediate health risks, of long-term harm posed by skin exposure, and of the overall health risk associated with pesticide use.

Table 5 presents odds ratios, 95% confidence intervals, and correlation coefficients for knowledge scores by applicators' perception of pesticide risks. Knowledge scores were not significantly associated with perceptions of fellow farmers personal protective equipment use, view that it is right to use personal protective equipment, avoidance of application if gear is not available, discussion of safety with other farmers, and avoid-

TABLE 2
Associations Between Farmers' Knowledge Scores and Their Intentions to Use Personal Protective Equipment During Pesticide Application (n = 127)

Behavioral Intentions	9–14* Correct (%)	15–18* Correct (%)	OR†	95% Confidence Interval	Spearman R
If I am considering using a new pesticide, I will be sure to get information on what personal protective gear is recommended before using that pesticide.					
Disagree	19.2	2.7	1.0	referent	
Agree	80.8	97.3	8.5	(1.7,81.6)	0.268‡
The next time I use pesticides I will wait until weather conditions are favorable.					
Disagree	3.9	2.7	1.0	referent	
Agree	96.1	97.3	1.4	(0.1,20.1)	−0.028
If the label instructions indicate to do so, will you wear a chemical resistant suit the next time you use pesticides?					
Disagree	44.4	28.8	1.0	referent	
Agree	55.6	71.2	2.0	(0.8,4.7)	0.164
If the label instructions indicate to do so, will you wear chemical resistant gloves the next time you use pesticides?					
Disagree	9.1	11.8	1.0	referent	
Agree	90.9	88.2	0.8	(0.2,3.0)	0.095
If the label instructions indicate to do so, will you wear a respirator or face shield the next time you use pesticides?					
Disagree	30.2	17.9	1.0	referent	
Agree	69.8	82.1	2.0	(0.7,5.4)	0.149
Will you have a supply of clean water with you the next time you use pesticides?					
Disagree	4.4	1.5	1.0	referent	
Agree	95.6	98.5	3.1	(0.1,186.5)	0.180‡

* Indicates no. of knowledge items answered correctly.
† Odds ratio for the association of high knowledge (15–18 correct) and agreement with the statement.
‡ Indicates a statistically significant Spearman Rank correlation coefficient at the $P < 0.05$ level.

ance of pesticide use if weather conditions are not favorable.

Table 6 presents odds ratios, 95% confidence intervals, and correlation coefficients for knowledge scores by applicators' self-efficacy beliefs regarding pesticide safety. Knowledge scores were significantly associated with confidence to prevent exposure of self (Spearman Rank P = 0.009) and family (Spearman Rank P = 0.034), confidence to avoid application during unfavorable wind conditions (Spearman Rank P = 0.011), and confidence to use the recommended personal protective equipment correctly (Spearman Rank P = 0.035). Individuals scoring higher in knowledge were more likely to report higher self-efficacy beliefs for each of these items. Knowledge scores were not significantly associated with confidence to get advice about safe handling and to obtain the recommended protective equipment.

Discussion

The measurement of pesticide safety knowledge in this investigation indicated less than optimal knowledge scores. A low frequency of correct responses to several precaution and hazard items was found in this sample. The knowledge scale was constructed using information that all applicators are responsible for achieving certification regarding knowledge of sources of exposure and contamination, handling practice guidelines pertaining to specific application contexts, and identification of hazards resulting from direct body contact with chemicals. Correct response percentages were less than 50% for two items and less than 80% for eight items, suggesting considerable gaps in safety knowledge in this sample.

The measures of intentions, beliefs, risk perceptions, peer norms, and self-efficacy were constructed by using behavioral domains found to be influential in other health behavior investigations.[11–18] The positive associations between knowledge and intention to get information about protective gear and to have clean water available during application indicated that higher levels of pesticide safety knowledge affected the intention to practice safety behavior during the next application. The negative associations between knowledge and the beliefs that one is too busy to use personal protective equipment and that exposure to pesticides is not carcinogenic were both ecologically valid and consistent with findings from other health be-

TABLE 3
Associations Between Farmers' Knowledge Scores and Their Beliefs About Use of Personal Protective Equipment During Pesticide Application (n = 127)

Beliefs	9–14* Correct (%)	15–18* Correct (%)	OR†	95% Confidence Interval	Spearman R
I'm too busy to use personal protective equipment when using pesticides.					
Disagree	68.0	88.9	1.0	referent	
Agree	32.0	11.1	0.3	(0.1,0.8)	−0.233‡
Direct exposure to pesticides is not harmful to human health.					
Disagree	98.0	98.6	1.0	referent	
Agree	2.0	1.4	0.7	(0.0,57.2)	0.004
A pesticide would not be put on the market if it weren't safe for humans to use.					
Disagree	66.0	65.7	1.0	referent	
Agree	34.0	34.3	1.0	(0.4,2.3)	0.037
Exposure to pesticides will not cause cancer.					
Disagree	95.0	100.0	1.0	referent	
Agree	5.0	0.0	0.0	(0.0,3.1)	−0.221‡

* Indicates no. of knowledge items answered correctly.
† Odds ratio for the association of high knowledge (15–18 correct) and agreement with the statement.
‡ Indicates a statistically significant Spearman Rank correlation coefficient at the $P < 0.05$ level.

TABLE 4
Associations Between Farmers' Knowledge Scores and Risk Perceptions About Use of Personal Protective Equipment During Pesticide Application (n = 127)

Risk Perceptions*	9–14† Correct (%)	15–18† Correct (%)	OR‡	95% Confidence Interval	Spearman R
How likely is it that getting pesticides on your skin will cause an immediate health risk?					
0–3	37.7	41.4	1.0	referent	
4–6	37.7	32.9	0.8	(0.3,2.0)	
7–10	24.5	25.7	1.0	(0.4,2.6)	−0.035
How likely is it that getting pesticides on your skin will cause long-term harm?					
0–3	19.6	21.4	1.0	referent	
4–6	51.0	34.3	0.6	(0.2,1.8)	
7–10	29.4	44.3	1.4	(0.5,4.3)	0.091
How would you rate the health risk associated with pesticide use?					
0–3	23.5	26.4	1.0	referent	
4–6	35.3	25.0	0.6	(0.2,1.9)	
7–10	41.2	48.6	1.1	(0.4,2.8)	−0.022

* Measured on a scale of 0–10, with 0 = very unlikely and 10 = very likely.
† Indicates no. of knowledge items answered correctly.
‡ Odds ratio for the association of high knowledge (15–18 correct) and agreement with the statement.

havior investigations.[22] The positive associations between knowledge and self-efficacy to prevent personal exposure, to prevent family exposure, to use recommended protective gear, and to avoid hazardous wind conditions showed that confidence to enact a protective behavior was influenced by overall knowledge about safety and hazards.

The absence of association between knowledge levels and perceptions of pesticide safety behaviors of other farmers suggests that the formation of peer norms is independent of individual knowledge. Farmers' perceptions of other farmer's safety behaviors may be based on direct observation and interaction with other farmers rather than their own amount of information about hazards and safety. The absence of association between knowledge levels and risk perceptions may also indicate that perceptions of risk are formed independently of individual information about hazards and may suggest an important distinction between information and perception.

TABLE 5
Associations Between Farmers' Knowledge Scores and Perceptions of Pesticide Safety by Their Peers (n = 127)

Peer Norms	9–14* Correct (%)	15–18* Correct (%)	OR†	95% Confidence Interval	Spearman R
Most of the farmers I know use personal protective equipment when using pesticides.					
Disagree	54.4	35.3	1.0	referent	
Agree	45.6	64.7	2.2	(1.0,5.0)	0.177
Using personal protective equipment is viewed by the farmers I know as the right thing to do.					
Disagree	2.0	4.23	1.0	referent	
Agree	98.0	95.8	0.5	(0.0,6.0)	−0.157
The farmers I know will not use pesticides if they don't have the recommended personal protective equipment.					
Disagree	75.5	68.7	1.0	referent	
Agree	24.5	31.3	1.4	(0.6,3.5)	0.113
Most of the farmers I know discuss pesticide safety with other farmers.					
Disagree	50.0	47.1	1.0	referent	
Agree	50.0	52.9	1.1	(0.5,2.5)	0.044
Most of the farmers I know will not use pesticides if weather conditions are not favorable.					
Disagree	11.3	15.3	1.0	referent	
Agree	88.7	84.7	0.7	(0.2,2.3)	−0.072

* Indicates no. of knowledge items answered correctly.
† Odds ratio for the association of high knowledge (15–18 correct) and agreement with the statement.

TABLE 6
Associations Between Farmers' Knowledge Scores and Their Self-Efficacy in Using Personal Protective Equipment During Pesticide Application (n = 127)

Self-Efficacy*	9–14† correct (%)	15–18† Correct (%)	OR‡	95% Confidence Interval	Spearman R
How confident are you that you are able to prevent yourself from being exposed to pesticides?					
0–7	50.9	32.9	1.0	referent	
8–10	49.1	67.1	2.1	(1.0,4.7)	0.215§
How confident are you that you are able to prevent your family from being exposed to pesticides?					
0–7	20.8	8.2	1.0	referent	
8–10	79.2	91.8	2.5	(0.8,8.8)	0.191§
If you were ready to spray pesticides and the wind came up how confident are you that you would be able to wait until the wind died down to spray?					
0–7	18.9	13.7	1.0	referent	
8–10	81.1	86.3	1.5	(0.5,4.2)	0.227§
If you needed advice on how to safely handle a given pesticide, how confident are you that you would be able to get that advice?					
0–7	13.2	2.7	1.0	referent	
8–10	86.8	97.3	5.4	(1.0,54.8)	0.094
How confident are you that you are able to obtain the recommended personal protective equipment?					
0–7	28.3	11.0	1.0	referent	
8–10	71.7	89.0	3.2	(1.1,9.2)	0.186
How confident are you that you are able to use the recommended personal protective equipment correctly?					
0–7	15.1	9.6	1.0	referent	
8–10	84.9	90.4	1.7	(0.5,5.6)	0.192§

* Measured on a scale of 0–10, with 0 = definitely cannot do and 10 = definitely can do.
† Indicates no. of knowledge items answered correctly.
‡ Odds ratio for the association of high knowledge (15–18 correct) and agreement with the statement.
§ Indicates a statistically significant Spearman Rank correlation coefficient at the $P < 0.05$ level.

Only a few published studies have focused on the psychosocial aspects of compliance with safe handling recommendations among applicators. One study of growers showed that attitudes toward protection had the greatest influence on behavior.[23] That study found that fruit growers who held the highest protection beliefs and evidenced these beliefs in protective behavior expressed the greatest receptivity to new ideas regarding pesticide protection. Stone and colleagues,[8] in a study of the use and care of pesticide protective clothing among applicators in five states, found that the majority of users were uncertain of pesticide associated health risks, their seriousness, and the effectiveness of their clothing in preventing exposure.

Although this study of pesticide applicators provides interesting new data on the relationship of objective knowledge with behavioral intentions and measures of self-efficacy, cautious inferences are warranted because of the cross-sectional nature of this study and the concomitant limitations in the analytic methods. The hypotheses generated in this analysis should be tested in prospective studies with sample sizes large enough to permit multivariate analyses capable of elucidating the interrelationships between knowledge, psychosocial predictors, and actual pesticide-related safety behaviors.

The psychosocial items constructed for this investigation measuring pesticide knowledge, attitudes, and intentions elucidate individual factors that affect occupational health behaviors. Variability in knowledge and discernible patterns of association between knowledge, intentions, beliefs, and self-efficacy in particular were identified. These behavioral measures have utility for studying other occupational health practices and for identifying behavioral outcomes to target in health promotion interventions. The results of this investigation add further support to the hypothesis that increasing pesticide safety knowledge levels among applicators will contribute to increasing safe handling behaviors.

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