Patterns of Pesticide Use among Farmers: Implications for Epidemiologic Research

Aaron Blair and Shelia Hoar Zahm

Epidemiologic studies of farmers have linked pesticides with certain cancers. Information on exposures from many of these studies was obtained by interview of farmers or their next-of-kin. The reliability and validity of data on pesticide use obtained by recall, often years after the event, have been questioned. Pesticide use, however, is an integral component in most agricultural operations, and the farmers' knowledge and recall of chemicals used may be better than for many other occupations. Contrary to general belief, many farmers typically use only a few pesticides during their lifetimes and make only a few applications per year. Data from U.S. Department of Agriculture surveys indicate that herbicides are applied to wheat, corn, soybeans, and cotton and that application of insecticides to corn averages two or fewer times per year. In epidemiologic studies at the National Cancer Institute, the proportion of farmers ever reporting lifetime use of five or more different chemicals was 7% for insecticides and 20% for herbicides. Surrogate respondents have often been used in epidemiologic studies of cancer; they are able to recall pesticide use with less detail than the farmers themselves. The pesticides reported by surrogates were the same as reported by subjects themselves, but with less frequency. Comparison of reporting by cases and controls provided no evidence of case-response (differential) bias; thus, inaccurate recall of pesticide use by subjects or surrogates would tend to diminish risk estimates and dilute exposure-response gradients. (Epidemiology 1993;4:55–62)

Keywords: pesticides, farmers, interviews, proxy respondents, misclassification, herbicides, data collection.

Epidemiologic studies from a number of countries indicate that farmers tend to be at higher risk for selected cancers than the general population.[1-3] These excesses occur despite a lower mortality among farmers for all causes combined and for most major causes of death. The specific agents in the agricultural environment that might be involved have not been clearly identified, but pesticides have received the most attention. There is good reason to focus on pesticides because the carcinogenic potential of a number of these chemicals has been demonstrated in animal bioassays. For about 50% of the pesticides evaluated, the International Agency for Research on Cancer has concluded that there is limited or sufficient evidence for carcinogenicity in experimental studies.[4] Similar findings have been obtained by the National Cancer Institute/National Toxicology Program (NCI/NTP), in which, of the 41 pesticides tested, six were positive in both sexes of two species, 10 were positive in both sexes of one species, six were positive in one sex of one species, and 19 gave no evidence of carcinogenicity.[5] These summaries can be viewed optimistically or pessimistically depending on whether you consider a 50% positive rate as reassuring or alarming. It underscores, however, the need to identify which pesticides are likely to pose a cancer risk to humans.

The surest way to identify carcinogenic pesticides already on the market is by epidemiologic investigations. In epidemiologic studies, the need to extrapolate from artificially high exposures and from one species to another is not required, as it is in animal bioassays. Epidemiologic studies, however, have limitations. The concerns raised regarding studies of pesticides and cancer usually focus on the limitations of exposure assessment and arise from a belief held by many that farmers cannot reliably report their exposure history.[6,7] Assembling information on past pesticide use in epidemiologic studies is difficult, and the reliability and validity of exposures reported retrospectively by subjects should be assessed.

Questions raised regarding exposure assessment in epidemiologic studies of agricultural use of pesticides include: (1) Can farmers accurately recall the pesticides they used from the large number of formulations on the market? (2) Is there corroborative evidence regarding the accuracy of reported use of pesticides by farm-

From the Occupational Studies Section, National Cancer Institute, Executive Plaza North, Room 418, Bethesda, MD 20892. Address reprint requests to: Aaron Blair.

Submitted June 5, 1992; final version accepted September 14, 1992.

ers? (3) What is the quality of information obtained from surrogate respondents? and (4) Does the pesticide history-taking technique, that is, open-ended *vs* probe, differentially affect reporting by cases and controls? In this paper, we use data from National Cancer Institute studies and other resources to address these issues.

Methods

The data for this paper come from U.S. Department of Agriculture (USDA) surveys and National Cancer Institute case-control studies of cancer in Kansas,[8] Iowa and Minnesota,[9,10] and Nebraska.[11] These three case-control studies had similar designs, including a population-based series of adult cancer cases (lymphatic and hematopoietic system and soft tissue sarcoma) with controls selected by random-digit telephone dialing (for living cases under age 65), from the Health Care Finance Administration (for living cases 65 or older), and from death certificates (for deceased cases). The studies in Iowa/Minnesota[9] and Kansas[8] included only white men, whereas the study in Nebraska[11] included white men and white women. Interviews were conducted with subjects, or their next-of-kin (if the cases were deceased or incapacitated), and they followed a structured format. The interviews in Iowa and Minnesota were in person, whereas those in Kansas and Nebraska were by telephone. In each investigation, we sought detailed information on specific pesticides used.

Each of the National Cancer Institute studies included methodologic components to address issues in exposure assessment of pesticides. In the Iowa/Minnesota study, interviews with both farmers and their wives were obtained for a sample of subjects.[10] In Kansas,[8] we sought interviews with pesticide suppliers for 130 farmers to evaluate comparability of reporting. In Nebraska,[11] we obtained information on pesticides that the subjects reported in response to an open-ended question that did not name specific pesticides. In this study, we also collected information on pesticides recalled only after the interviewer provided a prompt by naming the specific chemical.

Results

Number of Pesticides Used

Table 1 provides information on agricultural use of pesticides in 1990 on different crops.[12] For some of these crops, many acres are not treated every year; for example, two-thirds of the acres of wheat were not treated with any herbicide. Another USDA survey found that the proportion of farmers reporting no pesticide use in 1982 by crop was 14% for corn, 3% for cotton, 37% for sorghum, 7% for soybeans, 76% for oats, 65% for wheat, 86% for alfalfa, and 90% for pasture.[13] Table 1 shows that the average number of applications per year exceeded two only for herbicides on cotton. Finally, for any crop/pest combination, there are several pesticides that may be used, but a few products tend to dominate the market. Three or fewer different pesticides account for 30–70% of the treated acres for crops listed in Table 1. Applications are sometimes mixtures of pesticides, but this is a recent technique, and even now, mixed applications seldom include more than three chemicals.

TABLE 1. Pesticide use by crop, 1990*

Crop	Pesticide	% Acres Treated	Average Times Applied	% of Acres Treated by 3 Pesticides
Wheat	Herbicides	34	1.07	57
Corn	Herbicides	95	1.41	44
Corn	Insecticides	32	1.09	70
Soybeans	Herbicides (north)	97	1.48	34
Soybeans	Herbicides (south)	93	1.60	32
Cotton	Herbicides	94	2.07	49

* Data from U.S. Department of Agriculture (12).

Table 2 lists the major herbicides and insecticides used in agriculture, according to USDA surveys in 1966, 1971, and 1976.[14,15] Although there are over 25 insecticides and 25 herbicides listed, according to poundage, only a few are widely used. For example, five insecticides account for 70% of all use by weight in 1966, 70% in 1971, and 73% in 1976. For herbicides, the top five by weight accounted for 68% in 1971 and 82% in 1976. The rank order of the pesticides by weight also has not changed radically over time. Four of the top five insecticides in 1966 were still in the top five in 1971, and three in 1976. For herbicides, four of the top five in 1971 remained in the top five in 1976.

From interviews in an epidemiologic study in Iowa and Minnesota, we found that farmers did not report using large numbers of pesticides during their lifetimes. Forty-six per cent reported that they used no herbicides, 17% no insecticides, and 91% no fungicides (Table 3). Seventeen per cent, 42%, and 9% of the farmers reported that they had only used one herbicide, insecticide, or fungicide, respectively. Only 20% reported ever using five or more herbicides, 7% five or more insecticides, and 0% five or more fungicides. We found similar results from a study in Nebraska (data not shown).[11] Nineteen per cent of Nebraska farmers reported that they had used five or more herbicides, and 33% reported use of five or more insecticides.

TABLE 2. Amount (× 1000 Pounds) and Relative Ranking of Major Pesticides Used in Agriculture in 1966, 1971, and 1976*

Chemical†	Pounds (Rank) 1966	1971	1976
Insecticides			
Toxaphene	34,605 (1)	37,464 (1)	30,700 (1)
DDT	27,004 (2)	14,324 (4)	0
Aldrin	14,761 (3)	7,928 (6)	900 (13)
Carbaryl	12,392 (4)	17,838 (3)	9,300 (4)
Parathion	8,452 (5)	9,481 (5)	6,600 (5)
Methyl parathion	8,002 (6)	27,563 (2)	22,800 (2)
Diazinon	5,605 (7)	3,167 (12)	1,600 (9)
Malathion	5,218 (8)	3,602 (10)	Not provided
TDE (DDD)	2,896 (9)	244 (25)	Not provided
Methoxychlor	2,578 (10)	3,012 (13)	1,400 (11)
Strobane	2,016 (11)	216 (26)	Not provided
Ethion	2,007 (12)	2,326 (15)	Not provided
Disulfoton	1,952 (13)	4,079 (8)	5,500 (7)
Bidrin	1,857 (14)	807 (20)	300 (17)
Heptachlor	1,536 (15)	1,211 (18)	1,600 (9)
Azinphos-methyl	1,474 (16)	2,654 (14)	300 (17)
Trichorfon	1,060 (17)	617 (22)	Not provided
Dichlorvos	912 (18)	3,176 (11)	864 (14)‡
Endosulfan	791 (19)	882 (19)	800 (15)
Dieldrin	724 (20)	332 (24)	Not provided
Lindane	704 (21)	650 (21)	Not provided
Endrin	571 (22)	1,427 (17)	600 (16)
Chlordane	526 (23)	1,890 (16)	1,400 (11)
Ronnel	391 (24)	479 (23)	Not provided
Phorate	326 (25)	4,178 (7)	6,300 (6)
Bux	39 (26)	3,606 (9)	Not provided
Methomyl	0 (27)	0 (27)	2,500 (8)
Carbofuran	Not provided	Not provided	11,600 (3)
Herbicides (no data for 1966)			
Atrazine		57,216 (1)	90,300 (1)
2,4-D		33,252 (2)	38,400 (3)
Propachlor		23,730 (3)	11,000 (6)
Alachlor		14,754 (4)	88,500 (2)
Trifluralin		11,427 (5)	28,300 (4)
Amiben		9,555 (6)	4,400 (11)
Arsenicals		7,837 (7)	3,500 (15)
Propanil		6,656 (8)	6,900 (9)
Butylate		5,915 (9)	24,400 (5)
EPTC		4,409 (10)	8,600 (7)
Vernolate		3,736 (11)	Not provided
Fluometuron		3,334 (12)	5,300 (10)
Alanap		3,332 (13)	4,300 (12)
MCPA		3,284 (14)	Not provided
Propazine		3,171 (15)	3,900 (13)
Nitralin		2,706 (16)	Not provided
Linuron		1,803 (17)	8,400 (8)
Simazine		1,723 (18)	2,500 (16)
2,4,5-T		1,339 (19)	Not provided
Fluorodifer		1,330 (20)	Not provided
Norea		1,323 (21)	Not provided
Diuron		1,229 (22)	900 (17)
Pebulate		1,062 (23)	300 (18)
Dalapon		1,032 (24)	Not provided
Dicamba		420 (25)	3,600 (14)

* 1966 and 1971 data from Ref 14; 1976 data from Ref 15.

† Acronyms include: DDT, dichlorodiphenyltrichloroethane; TDE, tetrachlorodiphenylethane; DDD, dichlorodiphenyldichloroethane; 2,4-D, (2,4-dichlorophenoxy)acetic acid; EPTC, S-ethyl dipropylthiocarbamate; MCPA, 2-methyl-4-chlorophenoxyacetic acid; 2,4,5-T, (2,4,5-trichlorophenoxy)acetic acid.

‡ Based on use on livestock only.

TABLE 3. Number (and Proportion) of Different Pesticides Reported by Farmers (Controls Who Farmed at Age 25 or Older) in Iowa and Minnesota

No. of Pesticides Reported	Number (%)		
	Herbicides	Insecticides	Fungicides
0	280 (46)	104 (17)	553 (91)
1	102 (17)	254 (42)	55 (9)
2–4	104 (17)	206 (34)	0 (0)
5+	122 (20)	44 (7)	0 (0)

Reliability of Recall of Specific Pesticides Used

In the study in Kansas,[8] pesticide suppliers were interviewed to see whether they could corroborate information on pesticide use reported by farmers. We sought information from the major suppliers for 130 farmers. Interviews were completed with 110 suppliers (17 suppliers could not be located, and three said our subjects were not farmers, even though we had considerable information that they were). The agreement between suppliers and farmers regarding herbicide and insecticide use is shown in Table 4. Agreement was approximately 60% for cases and controls for use of both herbicides and insecticides. Agreement for years of insecticide use on major crops was also approximately 60%, whereas agreement for years of herbicide use was slightly lower, particularly for sorghum.

TABLE 4. Agreement between Farmers and Suppliers Regarding the Kansas Farmer's Use of Pesticides on Specific Crops

Pesticide/Crop	All Subjects		Controls		Cases	
	Number*	%	Number	%	Number	%
Ever used						
Herbicides	65/45	59	40/29	58	25/16	61
Insecticides	65/45	59	42/27	61	23/18	56
Years† of herbicide use on:						
Wheat	51/59	46	34/35	49	17/24	41
Corn	65/45	59	41/28	59	24/17	59
Sorghum	42/68	38	25/44	36	17/24	41
Pasture	58/52	53	37/32	54	21/20	51
Years† of insecticide use on:						
Wheat	67/33	61	42/17	61	25/16	61
Corn	69/41	63	41/28	59	28/13	68
Sorghum	61/49	55	39/30	57	22/19	54
Pasture‡						

* Number of agreements/number of disagreements.
† Years in categories of 0, 1–5, 6 or more, and unknown.
‡ Fewer than 5 users.

Accuracy of Reports from Surrogate Respondents

In each of the National Cancer Institute case-control studies,[8,9,11] we interviewed next-of-kin of deceased farmers to obtain information on the decedent's use of pesticides. Data from Iowa/Minnesota[9] in Table 5 show that surrogate respondents were approximately twice as likely as the farmers to respond "I don't know" to at least one pesticide from the list. Surrogates also reported use of fewer pesticides than did the farmers (Table 6). A larger proportion of surrogates than farmers reported no use of pesticides and three to five times as many farmers as surrogates reported using five or more herbicides or insecticides.

TABLE 5. Comparison of Farmer and Surrogate Respondents from Iowa and Minnesota Providing at Least One "Don't Know" Response Regarding Use of Specific Pesticides (Controls over Age 25)

Type of Pesticide*	% (Number) Giving at Least One "Don't Know" Response	
	Farmer Interview	Surrogate Interview
Herbicides	35 (150)	65 (140)
Crop insecticides	45 (180)	65 (145)
Animal insecticides	14 (55)	30 (65)

* Subjects were asked about 38 herbicides, 34 crop insecticides, and 30 animal insecticides.

TABLE 6. Comparison of the Number of Pesticides Used Reported by Farmers and Surrogate Respondents (Controls over Age 25 from Iowa and Minnesota)

Number Used	% (Number)	
	Farmer Interviews	Surrogate Interviews
Herbicides		
0	38 (148)	62 (132)
1	16 (62)	19 (40)
2–4	19 (75)	13 (29)
5+	27 (108)	7 (14)
Crop insecticides		
0	46 (182)	63 (136)
1	18 (72)	22 (48)
2–4	20 (80)	11 (24)
5+	15 (59)	3 (7)
Animal insecticides		
0	13 (52)	24 (152)
1	37 (147)	50 (107)
2–4	39 (155)	24 (51)
5+	10 (39)	2 (5)

MONGLY00371878

Table 7 compares the relative ranking of specific pesticides from subjects and surrogates by reporting frequency. The proportion of farmers reporting use of any specific chemical is typically two to five times larger than the proportion of surrogates. The rank order by number of times a specific chemical was reported by subjects and by surrogates, however, is quite similar, with Spearman correlation coefficients of 0.87 for herbicides, 0.71 for crop insecticides, and 0.80 for animal insecticides. When ranked by the number of persons reporting that the pesticide was used, the four most commonly reported herbicides [(2,4-dichlorophenoxy)acetic acid (2,4-D), atrazine, alachlor, and trifluralin] were reported in the same relative order for subjects and surrogates. The top four crop insecticides reported among farmers were in the top seven reported by surrogates, and four of the top five animal insecticides were the same for subjects and surrogates.

TABLE 7. Comparison of Reporting Frequency for Specific Pesticides from Farmers and Surrogate Respondents (Controls Who Farmed after the Age of 25 from Iowa/Minnesota)

	Farmer Interviews			Surrogate Interviews		
Pesticide*	No.	%	Rank	No.	%	Rank
Herbicides						
2,4-D	194	49	1	59	27	1
Atrazine	118	19	2	25	12	2
Alachlor	116	19	3	23	10	3
Trifluralin	103	26	4	17	8	4
Cyanazine	81	13	5	12	6	6
Dicamba	71	18	6	6	3	9
Chloramben	68	17	7	15	7	5
Bentazon	55	14	8	7	3	8
Glyphosate	53	13	9	2	1	11
Butylate	49	12	10	8	4	7
2,4,5-T	42	11	11	5	2	10
Crop insecticides						
Aldrin	95	24	1	13	6	3
DDT	64	16	2	26	12	1
Carbofuran	60	15	3	9	4	4
Phorate	48	12	4	6	2	7
Diazinon	40	10	5	6	3	7
Terbufos	39	10	6	4	2	12
Heptachlor	38	10	7	7	3	5
Copper arsenite	34	8	8	22	10	2
Fonofos	31	8	9	3	1	13
Carbaryl	30	8	10	6	3	7
Malathion	30	8	10	5	3	10
Dieldrin	26	7	12	2	1	15
Lindane	24	6	13	3	1	13
Chlordane	22	6	14	7	3	5
Lead arsenate	17	4	15	5	2	10
Toxaphene	15	4	16	0	0	17
Bufencarb	15	4	16	2	1	15
Animal insecticides						
Flyspray, NOS	236	60	1	129	60	1
DDT	106	27	2	45	21	2
Lindane	81	21	3	12	6	4
Malathion	59	15	4	9	4	5
Chlordane	37	9	5	4	2	6
Nicotine	36	9	6	13	6	3
Dichlorvos	35	9	7	3	1	7
Rotenone	21	5	8	1	<1	13
Famphur	17	4	9	3	1	7
Coumaphos	16	4	10	3	1	7
Toxaphene	16	4	10	3	1	7
Methoxychlor	15	4	12	2	1	12
Carbaryl	11	3	13	3	1	7
Ronnel	7	2	14	0	0	15
Dieldrin	6	2	15	1	<1	13
Trichlorfon	6	2	15	0	0	15

* See Table 2 for definitions of acronyms. NOS, not otherwise specified.

To compare directly responses from farmers with their next-of-kin surrogate respondents, we conducted interviews with wives and their farmer husbands (Table 8).[10] Surrogates tended to report fewer days per year of use of specific pesticides than the farmers. Correlations ranged from 0.23 to 0.80 for the different pesticides. Subjects and surrogate respondents agreed as to the category of frequency of use approximately 50–60% of the time, but it was better for more recent use, that is, after 1960, than for use before 1960.

Interview Technique: Open-Ended vs Probing with a List

In the Nebraska study,[11] subjects were first asked to respond to an open-ended question on their pesticide use. After they had volunteered all of the pesticides they could, the interviewer asked about the remaining

TABLE 8. Comparison of Farmers' and Their Spouses' Responses for Frequency of Pesticide Use*

Pesticide†	Used Before/After 1960	No. of Pairs	Correlation Coefficient	% Exact Agreement in Categories‡
Alachlor	After	25	0.80	52.0
Aldrin	After	30	0.63	66.7
Atrazine	After	30	0.78	60.0
Cyanazine	After	21	0.66	57.1
DDT	Before	23	0.23	30.4
Trifluralin	After	27	0.84	63.0
2,4-D	Before	26	0.30	48.4
	After	45	0.78	55.6
All herbicides		21	0.31	52.4
All insecticides		25	0.58	68.0

* Modified from Brown *et al.*[10]
† See Table 2 for definitions of acronyms.
‡ Categories for specific pesticides and all herbicides were 1–4, 5–9, and ≥10 days per year. Categories for all insecticides were 1–15, 16–60, and ≥61 days per year.

chemicals on a list previously developed by the investigators of commonly used pesticides to see whether this prompt could spark recall of having ever used the specific chemicals. A comparison of the number of pesticides mentioned in the open-ended questions with the number obtained from open-ended questions plus the prompts is shown in Table 9. This table includes farmers over the age of 25 who reported living on farms where pesticides were used. The number of pesticides volunteered by farmers was similar among cases and controls. Probing dramatically increased the number of pesticides reported. About 40% of the farmers who reported no use of insecticides or herbicides to the open-ended question responded positively to at least one of these chemicals when prompted with specific names. Among those who had volunteered no insecticides, 47% of the cases and 27% of the controls responded positively to at least one insecticide when prompted. Among farmers volunteering no use of herbicides, 49% of the cases and 38% of the controls were able to name at least one herbicide when prompted. The proportion of subjects reporting use of five or more pesticides also increased dramatically with probing. The distribution of the number of herbicides and insecticides reported from the open-ended question, however, was similar among cases and controls.

Table 10 displays volunteered *vs* probed information among cases and controls for selected pesticides. The proportion of farmers who volunteered that these pesticides were used was approximately equal among cases and controls, except for trifluralin, for which it was higher among controls. The proportions reporting use in response to prompts for specific pesticides were greater than the proportions from volunteered pesti-

TABLE 9. Number of Pesticides Reported from Open-Ended Questions (Volunteered) and Open-Ended plus Probed among Cases and Controls (White Male Farmers from Nebraska Age 26 or Older)

Pesticide and Number Used	Cases				Controls			
	Volunteered		Volunteered plus Probed		Volunteered		Volunteered plus Probed	
	Number	%	Number	%	Number	%	Number	%
Insecticides								
0	64	57	34	30	132	58	96	42
1	25	22	198	17	60	26	36	16
2-4	21	19	15	13	35	15	41	18
5+	2	2	45	40	1	<1	55	24
Total	113		113		228		228	
Herbicides								
0	35	38	18	20	84	49	52	30
1	30	33	19	21	41	24	35	20
2-4	22	24	27	30	42	24	41	24
5+	4	4	27	30	5	3	44	26
Total	91		91		172		172	

TABLE 10. Farmers' Reported Use of Selected Pesticides When Volunteered *vs* Probed by Case and Control Status (White Men from Nebraska)

Pesticide*	Cases				Controls			
	Volunteered		Probed		Volunteered		Probed	
	Number	%	Number	%	Number	%	Number	%
Insecticides								
DDT	16	33	33	67	38	41	54	59
Terbufos	7	33	14	67	8	30	19	70
Herbicides								
Alachlor	12	36	21	64	22	41	32	59
Cyanazine	3	19	13	81	9	26	25	74
2,4-D	47	64	26	36	74	64	42	36
Trifluralin	4	24	13	76	15	44	19	56

* See Table 2 for definitions of acronyms.

cides alone, except for 2,4-D. Sixty-four per cent of the cases and controls volunteered use of 2,4-D *vs* only 36% of those requiring a probe.

Discussion

The Federal Insecticide, Fungicide, and Rodenticide Act Amendment of 1988 mandated the review of the approximately 24,000 registered pesticide products on the market.[16] This large number may contribute to the general perception that each farmer uses many different pesticides each year. This impression, coupled with a belief that the specific pesticides used change from year to year, raises doubts regarding the validity of information on pesticide use obtained by interview. Obviously, if individual farmers used even a fraction of the pesticides available, it would be doubtful whether they could accurately recall the majority of them.

The number of different pesticides used on many agricultural commodities, however, is small. Data from USDA surveys and our epidemiologic studies indicate that, despite the availability of thousands of chemicals, the number of pesticides used by farmers is typically 10 or fewer rather than hundreds. Data from USDA also indicate that the specific pesticides used did not change radically between 1966 and 1976, at least for some types of agricultural commodities. Even for commodities for which pesticides are heavily used, such as vegetables, three or fewer chemicals typically account for 50% or more of the total amount of herbicides, insecticides, or fungicides used by weight.[17] The time period 1966–1976 was a time when rapid change might have been expected because of the shift from use of organochlorine to organophosphate insecticides. From 1966 to 1976, the share of the market for organochlorine insecticides on major crops dropped from 70% to 29%, whereas organophosphates rose from 22% to 49% and carbamates from 7% to 19%.[18] Thus, even during this period of relative instability, the problem of sorting out pesticide exposures in agriculture is probably no more difficult than for other exposures in many industrial situations. Studies in agriculture may possess a distinct advantage because farmers, who function as both owner and operator, may be able to provide more information on exposure than could usually be obtained from either workers or supervisors in industrial facilities. Farmers' use of pesticides is based on operational needs, and, consequently, they make reasoned decisions regarding pesticide use. Farmers must decide whether there is a pest problem, select the pesticide most likely to be effective, purchase the pesticide, record the purchase (costs are tax deductible), mix and apply the pesticide, and evaluate the success of the treatment. These activities tend to reinforce memory.

Methodologic efforts are needed, however, to assess the actual reliability and accuracy of farmers' reported use of pesticides. Our comparison of information from farmers with information from their pesticide suppliers indicates a moderate level of correspondence. It is important to remember, however, that the information from suppliers does not constitute a "gold standard." Thus, the overall accuracy of reports from farmers is probably better than suggested by this comparison, because some of the disagreement between farmers and suppliers must be due to errors from the suppliers.

Because of the rapidly fatal nature of many cancers, epidemiologic studies often must include interviews with surrogate respondents. For some factors of epidemiologic interest (for example, tobacco use), surrogates can provide reliable information. The accuracy of information on agricultural use of pesticides obtained from surrogates, however, is unknown. In one of our studies, we found that surrogate respondents were a poorer source of information than farmers themselves.[9] They reported a smaller number of pesticides ever used and a smaller proportion of farmers who used any specific pesticide, and they had a greater propensity to give an "I don't know" response. Studies including surrogate respondents, therefore, would have lower study power because fewer subjects would be classified as exposed. Interviews with the farmers themselves is obviously preferred. Interestingly, however, the rank orders of specific pesticides by the number of surrogates and subjects reporting the chemicals used were quite similar. This finding indicates that the chemicals reported by surrogates may essentially be the same as reported by farmers, but with lower absolute frequency. In the absence of evidence of case-response bias, it appears that errors associated with the reported use of pesticides would tend to bias risk estimates toward the null.[19]

Differential information bias is a concern in case-control studies.[19] Publicity about pesticides and disease and the tendency of individuals with cancer to try to identify events in their life that may have caused their disease could result in case-response bias. This bias moves risk estimates away from the null and could create false-positive findings. If case-response bias were a problem, we might anticipate that cases would be better prepared than controls to volunteer pesticides which they believed were associated with their disease and to recall more pesticides on open-ended questions. The number of insecticides and herbicides volunteered

MONGLY00371881

by cases and controls, however, was quite similar, providing no support for this contention.

Data presented here indicate that the major problems in assessing agricultural pesticide exposure based on information obtained from interviews would result in nondifferential misclassification. This error tends to bias risk estimates toward the null and to dilute exposure response gradients. It may cause false-negative results, but it is unlikely, although not impossible,[20] to result in false-positive findings. The approach that one should take to minimize effects of misclassification errors on risk estimates depends upon the prevalence of the exposure of interest in the population.[21] When the prevalence of exposure is low, the critical concern is to avoid classifying unexposed subjects as exposed. If the exposure prevalence is high, the reverse is true. Since some agricultural pesticides may be used quite commonly and others infrequently, it may not be possible to have a single classification system across all pesticides.

Prospective studies of farmers would provide one solution to the misclassification problem, since periodic assessment of exposures would reduce the problem of long-term recall. Prospective studies could also be used to determine the magnitude of exposure misclassification from retrospective assessments, which would be invaluable in evaluating results from case-control studies. The National Cancer Institute, in collaboration with the Environmental Protection Agency and the National Institute of Environmental Health Sciences, is initiating a long-term prospective study of farmers, plus their spouses and children, to assess agricultural and life-style factors that may present hazards to farm families.

References

1. Blair A, Malker H, Cantor KP, Burmeister L, Wiklund K. Cancer among farmers: a review. Scand J Work Environ Health 1985;11:397–407.
2. Pearce N, Reif JS. Epidemiologic studies of cancer in agricultural workers. Am J Ind Med 1990;18:133–142.
3. Blair A, Zahm SH. Cancer among farmers. In: Cordes DH, Rea DF, eds. Health Hazards of Farming. Occupational Medicine: State of the Art Reviews. vol. 6. Philadelphia: Hanley & Belfus, 1991;335–354.
4. International Agency for Research on Cancer. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. Overall Evaluations of Carcinogenicity: An Updating of IARC Monographs Volumes 1 to 42. Lyon: International Agency for Research on Cancer, 1987.
5. Hoover RN, Blair A. Pesticides and cancer. In: Devita V, Hellman S, Rosenberg S., eds. Cancer Prevention. Philadelphia: JB Lippincott, 1991;1–11.
6. Council for Agricultural Science and Technology. Perspectives on the Safety of 2,4-D. Ames, IA: Council for Agricultural Science and Technology, December 1987.
7. Blair A, Zahm SH. Methodologic issues in exposure assessment for case-control studies of cancer and herbicides. Am J Ind Med 1990;18:285–293.
8. Hoar SK, Blair A, Holmes FF, Boysen CD, Robel RJ, Hoover RN, Fraumeni JF Jr. Agricultural herbicide use and risk of lymphoma and soft tissue sarcoma. JAMA 1986;256:1141–1147.
9. Brown LM, Blair A, Gibson R, Everett GD, Cantor KP, Schuman LM, Burmeister LF, Van Lier SF, Dick F. Pesticide exposures and other agricultural risk factors for leukemia among men in Iowa and Minnesota. Cancer Res 1990;50:6585–6591.
10. Brown LM, Dosemeci M, Blair A, Burmeister L. Comparability of data obtained from farmers and surrogate respondents on use of agricultural pesticides. Am J Epidemiol 1991;134:348–355.
11. Zahm SH, Weisenburger DD, Babbitt PP, Saal RC, Vaught JB, Cantor KP, Blair A. A case-control study of non-Hodgkin's lymphoma and the herbicide 2,4-dichlorophenoxyacetic acid (2,4-D) in eastern Nebraska. Epidemiology 1990;1:349–356.
12. U.S. Department of Agriculture. Agricultural Resources: Inputs Situation and Outlook. Report AR-21. Washington DC: Economic Research Service, 1991.
13. Duffy M. Pesticide Use and Practices, 1982. USDA Econ Res Ser (Agric. Inform. Bull. No. 462). Washington DC: U.S. Government Printing Office, 1982.
14. Andrilenas PA. Farmers' Use of Pesticides in 1971. USDA Agricultural Economic Rep. No. 252. Washington DC: U.S. Government Printing Office, July 1974.
15. Eichers TR, Andrilenas PA, Anderson TW. Farmers' Use of Pesticides in 1976. USDA Agricultural Economic Rep. No. 418. Washington DC: U.S. Government Printing Office, December 1978.
16. U.S. General Accounting Office. Lawn Care Pesticides. GAO/RCED-90-134. Washington DC: U.S. Government Printing Office, 1990.
17. Ferguson WL. 1979 Pesticide Use on Vegetables in Five Regions. USDA Econ Res Serv Staff Rep. No. AGES830920. Washington DC: U.S. Government Printing Office, January 1984.
18. Osteen CD, Szmedra PI. Agricultural Pesticide Use Trends and Policy Issues. USDA Agricultural Economic Rep. No. 622. Washington DC: U.S. Government Printing Office, 1989.
19. Checkoway H, Pearce NE, Crawford-Brown DJ. Research Methods in Occupational Epidemiology. New York: Oxford University Press, 1989.
20. Dosemeci M, Wacholder S, Lubin JH. Does nondifferential misclassifiction of exposure always bias a true effect toward the null value? Am J Epidemiol 1990;132:746–748.
21. Stewart WF, Correa-Villaseñor A. False positive exposure errors and low exposure prevalence in community-based case-control studies. Appl Occup Environ Hyg 1991;6:534–540.

Thank you for your recent purchase with Infotrieve. Please contact us with the Infotrieve Order ID if you have questions or comments.Email: customerservice@infotrieve.com
Phone: 800-422-4633; 203-423-2175 (toll)

ORDER INFORMATION SUMMARY:
Infotrieve Order ID: 2170241 / Cart ID: 1252065
Copies: 1
Ordered By: Onassis
Ordered By Email: onassis.falanda.moore@monsanto.com
Order Time: 5/8/2012 3:06 PM
Bill Ref: SALTMIRAS, DAVID A
Cost Center: SLB76567
Customer Order Number:
Urgency: Panic
Total Fee: $81.50
Genre: Article
Type: Doc Del (Journal Article)

ARTICLE INFORMATION:
Title: Patterns of pesticide use among farmers: implications for epidemiologic research
Authors: Blair, A; Zahm, S H
Pub Name: Epidemiology
Std Num: 10443983
Volume: 4
Issue: 1
Pages: 55-62
Supplement:
Pub Date: 1/1993

Copyright Terms: