t and L. Andersson. 1995. Air quality, working
ier rearing system for pullets. Swedish University
Agricultural Biosystems and Technology, Special
ith English summary).
Vorking conditions related to the air quality in
, 7-9 November 1994, Kolbotn, Norwa
: Nordic Association of Agricultural Sc
ırd. 1985. Air quality in commercial lay

ice 1991. Respiratory symptoms and p
ıfinement units. *Am. J. Ind. Med.* 19(2):
ig and J. A. Janni. 1987. Aspergillus
y confinement buildings. *Am. Ind. Hy*

onal Safety and Health. 1996. Occ
Sweden
ark. 1988. Air quality and contaminan
n. Agric. Eng. 30(2):273-276.
Mull. 1982. Occupational exposure to
xicol. Environ. Health 9(2):339-345.
C. Lax Hoerner. 1988. Airborne e
of protein products in gram-negative

P. Malmberg. 1986. Collection of
nation and analysis — CAMNEA n

ındholm. 1989. Endotoxin levels in
levels. *Br. J. Ind. Med.* 46(6):412-416.
reactions after exposure to cotton du

xposures. *Am. J. Ind. Med.* 17(1):39-4
n: Swedish Book of Statues. SFS 198
ung reactions during poultry handli
Resp. Dis. 65(4):266-271.
ırpenter. 1991. Air hygiene in a pullet house:
and in vitro. *Br. Poultry Sci.* 32(1):31-46.
ey. 1993. Air pollutant burdens and respiratory
Proc. Livestock Environment IV, Fourth Intl.
)9-716. St. Joseph, Mich.: ASAE.
Rowland. 1997. Respirable tissue damage in
icles and ammonia. In *Proc. 5th Intl. Symp.*
r and S. J. Hoff, 647-654. St. Joseph, Mich.:

ord. 1994. Airborne environmental endotoxin:
techniques. *Appl. Env. Microbiol.* 60(3):996-

Comparison of Two Techniques to Obtain Information on Pesticide Use from Iowa Farmers by Interview

A. Blair, P. A. Stewart, B. Kross, L. Ogilvie, L. F. Burmeister, M. H. Ward, S. H. Zahm

Abstract

A methodologic study was conducted in Iowa to evaluate the quality of information on pesticide use provided by farmers and their spouses. Included in this project was an assessment of the amount of detail farmers could provide in interviews regarding agricultural use of pesticides and to evaluate whether a volunteer or probe interviewing technique elicited the best response. Interviews were conducted with 203 farmers to obtain information on type, amount, and timing of pesticides used. In the interviews farmers first volunteered the names of pesticides they had used. Interviewers then probed for possible use of pesticides not already mentioned. Probing yielded a considerable number of additional positive responses, e.g., from 12% of the total number of farmers reporting use of atrazine to 89% for chlordane. This indicates that questionnaires based on an approach where farmers volunteered the names of individual chemicals used, i.e., provided names without interviewer prompts, are likely to be less complete. Many farmers were able to provide information on amount of pesticide purchased, application rate employed, and acres treated. A larger proportion, however, provided "don't know" responses to the questions about amount of pesticide purchased (6% to 27%) and amount of active ingredient used (7% to 20%).

Keywords. Pesticides, Farmers, Epidemiology, Epidemiologic methods, Reliability, Interviews, Surrogate respondents.

Interviews with farmers have been used in a number of epidemiologic studies designed to evaluate cancer risks from agricultural pesticide exposures (Brown et al., 1990; Cantor et al., 1992; Hardell and Sandstrom, 1979; Hoar et al., 1986; Pearce et al., 1986; Zahm et al., 1990). Farmers are knowledgeable about pesticide use because this activity is an integral part of their farming operation and has important economic consequences. Few studies, however, have evaluated the amount of detail farmers can provide or the quality of information obtained from interviews with farmers (Blair and Zahm, 1993). We conducted a methodologic study among a stratified sample of Iowa farmers to obtain information that could be used in designing more reliable and accurate questionnaires for epidemiologic investigations focusing on pesticide exposures, to evaluate results from different

The authors are Aaron Blair, PhD, Patricia A. Stewart, PhD, Mary H. Ward, PhD, and Shelia Hoar Zahm, ScD, Occupational Epidemiology Branch, National Cancer Institute, Bethesda, MD; and Burton Kross, PhD, Linda Ogilvie, MS, and Leon F. Burmeister, PhD, Department of Preventive Medicine, University of Iowa, Iowa City, Iowa. Corresponding author: Dr. Aaron Blair, National Cancer Institute, EPN Room 418, Bethesda, MD 20892-7364; tel.: (301) 496-9094; fax: (301) 402-1819; e-mail: <blaira@epndce.nci.nih.gov>.

interviewing techniques, and to test the limits of farmers ability to respond by seeking detailed information on pesticide practices.

Methods

Interviews were sought with 263 male Iowa farmers aged 30 to 84, and 203 were obtained (a response rate of 77%). Interviews averaged 100 min in length. The details of the design of this project have been presented elsewhere (Blair et al., 1995). Briefly, these 203 participants included 165 farmers interviewed from a stratified, random sample of 225 farmers selected from a geographic grid to identify farm locations for a study of nitrate contamination of well water (Kross et al., 1993), plus 38 additional farmers, selected on the basis of their proximity to the University of Iowa, who agreed to participate in the pesticide monitoring phase of the project.

In-person interviews with farmers were conducted during 1990 and 1991 using a questionnaire specifically developed to solicit more information about their pesticide use than had been attempted previously in epidemiologic investigations. In addition to questions asked in previous epidemiologic investigations such as ever use and days per year of use for 20 herbicides and 20 insecticides (typically using both trade and common names), details were sought on use by decade, application techniques, amount of active ingredient applied, amount purchased, container size, acres of crops or number of livestock treated, equipment used, precautions taken, cleanup techniques, accidents recalled, and occurrence of pesticide-related symptoms for three commonly used herbicides, i.e., atrazine, alachlor, and 2,4-D. Information was also collected on childhood farm activities, educational background, availability of records on pesticides, and the subject's knowledge and beliefs about pesticides and disease.

During the interview farmers were first asked to volunteer any pesticides they used without the interviewer naming each chemical. After recording all pesticides volunteered by the subject, the interviewers probed for use of the remaining pesticides on the list by reading each one.

The proportion of "don't know" responses for certain questions was used as an indication of the subject's ability to provide responses to various questions on pesticide use, a technique which has been used in other methodologic projects (Pickle et al., 1983).

Frequency of use and other practices were analyzed as median days per year because the distributions were not normal. The relationship between the proportion of farmers requiring a probe and the prevalence of use was evaluated by Pearson product-moment correlations.

Results

About 90% of the farmers were married, 33% had more than a high school education, and 90% had been a farm operator for 10 or more years. Table 1 shows reported use of major agricultural herbicides and insecticides. A larger percentage of the subjects reported using herbicides [e.g., atrazine (88%), alachlor (89%) and 2,4-D (95%)] than insecticides [e.g., terbufos (35%), carbofuran (28%), and phorate (28%)]. The median number of days per year various pesticides were used was 4 or less. For several chemicals (i.e., atrazine, dicamba, cyanazine, EPTC +, alachlor, glyphosate, trifluralin, 2,4-D, terbufos, fonofos, carbofuran, chlorpyrifos, malathion and phorate), however, some individual farmers reported use of 20 or more days per year. The median number of days per year of use differed little between those who

Table 1. Characteristics of reporte

Trade Name (Common Name)	Number (%) of Farmers Reporting Use	Percent That Volunteer Use	Pc from
			H
Aatrex (Atrazine)	179 (88)	88	
Amiben (Chloramben)	96 (47)	51	
Banvel (Dicamba)	136 (67)	61	
Basagran (Bentazon)	114 (56)	54	
Bicep (Atrazine/ Metolachlor)	39 (19)	59	
Bladex (Cyanazine)	151 (74)	72	
Blazer (Acifluorfen)	25 (12)	40	
Buctril (Bromoxynil)	25 (12)	59	
Conquest (Glufosinate)	6 (3)	67	
Dual (Metolachlor)	93 (46)	82	
Eradicane (EPTC +)	64 (32)	64	
Fusilade (Fluazifop-butyl)	38 (19)	32	
Lasso (Alachlor)	180 (89)	81	
Marksman (Atrazine/ Dicamba)	21 (10)	67	
Poast (Sethoxydim)	48 (24)	44	
Ramrod (Propachlor)	49 (24)	49	
Roundup (Glyphosate)	130 (64)	31	
Treflan (Trifluralin)	140 (69)	84	
(2,4-D)	193 (95)	67	
			I
(Aldrin)	26 (13)	35	
(Chlordane)	11 (5)	11	
Counter (Terbufos)	72 (35)	79	
Dyfonate (Fonofos)	48 (24)	77	
Furadan (Carbofuran)	57 (28)	65	
(Heptachlor)	10 (5)	30	
Lorsban (Chlorpyrifos)	48 (24)	75	
(Malathion)	26 (13)	15	
Thimet (Phorate)	57 (28)	82	

he limits of farmers ability to respond by
e practices.

thods

e Iowa farmers aged 30 to 84, and 203 were
erviews averaged 100 min in length. The
ve been presented elsewhere (Blair et al.,
included 165 farmers interviewed from a
selected from a geographic grid to identify
amination of well water (Kross et al., 1993),
e basis of their proximity to the University
pesticide monitoring phase of the project.
e conducted during 1990 and 1991 using a
licit more information about their pesticide
in epidemiologic investigations. In addition
gic investigations such as ever use and days
insecticides (typically using both trade and
n use by decade, application techniques,
unt purchased, container size, acres of crops
ment used, precautions taken, cleanup
nce of pesticide-related symptoms for three
alachlor, and 2,4-D. Information was also
cational background, availability of records
and beliefs about pesticides and disease.
rst asked to volunteer any pesticides they
h chemical. After recording all pesticides
iewers probed for use of the remaining

nses for certain questions was used as an
ovide responses to various questions on
en used in other methodologic projects

were analyzed as median days per year
. The relationship between the proportion
valence of use was evaluated by Pearson

ults

ried, 33% had more than a high school
rator for 10 or more years. Table 1 shows
es and insecticides. A larger percentage of
., atrazine (88%), alachlor (89%) and 2,4-
s (35%), carbofuran (28%), and phorate
ear various pesticides were used was 4 or
dicamba, cyanazine, EPTC +, alachlor,
ofos, carbofuran, chlorpyrifos, malathion
mers reported use of 20 or more days per
of use differed little between those who

Table 1. Characteristics of reported pesticide use by Iowa farmers (N = 203)

Trade Name (Common Name)	Number (%) of Farmers Reporting Use	Percent That Volunteer Use	Percent from a Probe	Median Days per Year from Volunteers	Median Days per Year from Probes	Major Crop Treated and (% Used on That Crop)
			Herbicides			
Aatrex (Atrazine)	179 (88)	88	12	4	2	Corn (90%)
Amiben (Chloramben)	96 (47)	51	49	3	2	Beans (74)
Banvel (Dicamba)	136 (67)	61	39	2	2	Corn (81)
Basagran (Bentazon)	114 (56)	54	46	2	2	Beans (86)
Bicep (Atrazine/ Metolachlor)	39 (19)	59	41	3	3	Corn (75)
Bladex (Cyanazine)	151 (74)	72	28	3	2	Corn (89)
Blazer (Acifluorfen)	25 (12)	40	60	2	2	Beans (60)
Buctril (Bromoxynil)	25 (12)	59	41	2	2	Corn (79)
Conquest (Glufosinate)	6 (3)	67	33	4	3	Corn (32)
Dual (Metolachlor)	93 (46)	82	18	4	4	Corn (56)
Eradicane (EPTC +)	64 (32)	64	36	2	2	Corn (83)
Fusilade (Fluazifop-butyl)	38 (19)	32	68	1	2	Beans (68)
Lasso (Alachlor)	180 (89)	81	19	4	2	Corn (47)
Marksman (Atrazine/ Dicamba)	21 (10)	67	33	3	3	Corn (62)
Poast (Sethoxydim)	48 (24)	44	56	1	1	Beans (75)
Ramrod (Propachlor)	49 (24)	49	51	3	3	Corn (71)
Roundup (Glyphosate)	130 (64)	31	69	2	2	Beans (32)
Treflan (Trifluralin)	140 (69)	84	16	3	2	Beans (84)
(2,4-D)	193 (95)	67	33	3	3	Corn (48)
			Insecticides			
(Aldrin)	26 (13)	35	65	3	2	Corn (63)
(Chlordane)	11 (5)	11	89	2	2	Buildings (25)
Counter (Terbufos)	72 (35)	79	21	4	2	Corn (86)
Dyfonate (Fonofos)	48 (24)	77	23	3	5	Corn (80)
Furadan (Carbofuran)	57 (28)	65	35	3	4	Corn (81)
(Heptachlor)	10 (5)	30	70	3	4	Other (54)
Lorsban (Chlorpyrifos)	48 (24)	75	25	5	4	Corn (80)
(Malathion)	26 (13)	15	85	2	1	Bins (34)
Thimet (Phorate)	57 (28)	82	18	4	4	Corn (83)

volunteered information and those requiring a probe. For most pesticides, corn or soybeans were the commodity most often treated. Exceptions occurred for chlordane, malathion, and heptachlor where treatment of buildings, grain bins, and other areas, were the more commonly reported uses. The proportion of farmers who required a probe to recall use varied by pesticide, but it was similar for insecticides (average of 44%) and herbicides (average of 40%). Among farmers who reported use of the herbicides atrazine, metolachlor, alachlor, and trifluralin and the insecticides terbufos, fonofos, and phorate, about 80% volunteered the information. Over 50% of the users required a probe from the interviewer before mentioning they used the herbicides acifluorfen, fluazifop-butyl, sethoxydim, propachlor, glyphosate and the insecticides aldrin, chlordane, heptachlor, and malathion. The correlation between the proportion requiring a probe and the reported prevalence of use of pesticides was $r = 0.56$ ($p < 0.01$).

We also evaluated the proportion of subjects volunteering information on the use of individual pesticides by age, i.e., less than 50 and 50 or more years old, to see if age affected recall. The proportion of users who volunteered the information was similar for the two age groups

Farmers were asked more detailed questions regarding three of the major herbicides used in Iowa, i.e., atrazine, alachlor, and 2,4-D. For each of these chemicals, we asked in which calendar years the chemicals had been used by decade from the 1950s to 1990s. The proportion of farmers who reported ever using these herbicides by decade was 3% (N = 8), 27% (N = 64), 54% (N = 129), 57% (N = 138), and 28% (N = 68) for the 1950s, 1960s, 1970s, 1980s, and in 1990, respectively for atrazine; 1% (N = 3), 11% (N = 27), 46% (N = 110), 57% (N = 138), and 12% (N = 30)for alachlor; and 20% (N = 47), 42% (N = 102), 69% (N = 165), 71% (N = 171), and 47% (N = 114) for 2,4-D. The proportion of farmers who reported that they had used these pesticides every year from 1970 through 1990 was 25% for atrazine, 12% for alachlor, and 40% for 2,4-D. The average number of hours per year spent mixing or applying atrazine, alachlor, and 2,4-D were 25, 24, and 20 h, respectively.

Table 2 summarizes information obtained on the details of use for the three herbicides in the 1960s and 1980s. Although, median values for the number of pounds purchased and acres treated with atrazine increased from the 1960s to the 1980s, the rate of application of the active ingredient decreased. The rate of application for 2,4-D, however, showed little change. Dividing the number of pounds purchased by the number of acres treated results in a pounds per acre number roughly equivalent to the pounds per acre provided directly in the interview. For atrazine and 2,4-D, the number of acres treated per hour increased between the 1960s and the 1980s, but only small changes occurred for alachlor. Farmers reported

Table 2. Median values for factors associated with use of three herbicides by Iowa farmers in the 1960s and 1980s

	1960s			1980s		
Pesticide Use Factor	Atrazine (N = 64)	Alachlor (N = 27)	2,4-D (N = 102)	Atrazine (N = 138)	Alachlor (N = 138)	2,4-D (N = 171)
Lb/acre of active ingredient	2.0	9.0	0.5	1.5	7.0	0.5
Lb purchased	200	700	NA	250	500	NA
Acres treated	125	100	90	169	100	65
Acres treated per hour	10	5	10	15	5	15
Tank size in gallons	200	150	200	400	200	200

NA = not applicable because amounts purchased in gallons instead of pounds.

a considerable increase in tank size
and 1980s, but little change for equi
We evaluated the relationship
amount of pesticide purchased. On
numbers for evaluation. The corre
treated with atrazine and amount pu
The proportion of "don't know
evaluate the ability of farmers to
(table 3). Farmers had little difficul
ever applied the herbicide, acres tre
responses were generally less than 5
had difficulty recalling the amou
purchased with the proportion of "
(range from 3% to 27%). There w
herbicide use in the 1980s than durin
As part of the effort to evaluate th
the interviewers and the subjects to r
various topics (table 4). Farmers felt t
fairly accurately or very accurately
accuracy of pesticide use in the 1960s
(89% fairly or very accurate). They als
worked with herbicides each year wa
were fairly confident of the informatic

Di

Interviews with farmers have
agricultural chemical use for agricultu
of Agricultural (USDA) has used inte
acres of specific crops or livestock be
amount applied, form of the purchas
target pest (Andrilenas, 1974; Eiche
typically seek information on pesticide
farmers can provide such informatio
chronic diseases have also used intervi
of pesticides (Hoar al., 1986; Brown e
1992), but these surveys seek informa

Table 3. Percent* and (number) of "d
on herbicide applica

	1960	
Pesticide Use Factor	Atrazine (N = 64)	Alach (N = 2
Used	<1 (1)	0 (0
Amount active ingredient used	13 (9)	20 (6
Amount purchased	17 (12)	27 (8
Container size	12 (8)	0 (0
Total acres treated	4 (3)	7 (2
Acres treated per hour	7 (5)	7 (2
Size of sprayer tank	4 (3)	3 (1)

*Percent of subjects reporting use of the chemical b

ıring a probe. For most pesticides, corn or
often treated. Exceptions occurred for
ıere treatment of buildings, grain bins, and
ıorted uses. The proportion of farmers who
›esticide, but it was similar for insecticides
of 40%). Among farmers who reported use
lachlor, and trifluralin and the insecticides
volunteered the information. Over 50% of
ᴣrviewer before mentioning they used the
thoxydim, propachlor, glyphosate and the
, and malathion. The correlation between
'eported prevalence of use of pesticides was

bjects volunteering information on the use
ıan 50 and 50 or more years old, to see if
ers who volunteered the information was

questions regarding three of the major
alachlor, and 2,4-D. For each of these
.rs the chemicals had been used by decade
of farmers who reported ever using these
(N = 64), 54% (N = 129), 57% (N = 138),
970s, 1980s, and in 1990, respectively for
(N = 110), 57% (N = 138), and 12% (N =
√ = 102), 69% (N = 165), 71% (N = 171),
ion of farmers who reported that they had
through 1990 was 25% for atrazine, 12%
ʒe number of hours per year spent mixing
:re 25, 24, and 20 h, respectively.
ined on the details of use for the three
ough, median values for the number of
ıtrazine increased from the 1960s to the
tive ingredient decreased. The rate of
little change. Dividing the number of
es treated results in a pounds per acre
er acre provided directly in the interview.
:s treated per hour increased between the
:s occurred for alachlor. Farmers reported

vith use of three herbicides by Iowa farmers
ınd 1980s

	1980s		
2,4-D (N = 102)	Atrazine (N = 138)	Alachlor (N = 138)	2,4-D (N = 171)
0.5	1.5	7.0	0.5
NA	250	500	NA
90	169	100	65
10	15	5	15
200	400	200	200

ɔns instead of pounds.

a considerable increase in tank size related to atrazine application between the 1960s and 1980s, but little change for equipment used for alachlor and 2,4-D.

We evaluated the relationship between reported number of acres treated and amount of pesticide purchased. Only the corn/atrazine combination had sufficient numbers for evaluation. The correlation was 0.37 ($P < 0.001$) for acres of corn treated with atrazine and amount purchased in 1960 and 0.56 ($P < 0.0001$) for 1980.

The proportion of "don't know" responses to selected questions was used to evaluate the ability of farmers to provide detailed information on pesticide use (table 3). Farmers had little difficulty responding to the questions on whether they ever applied the herbicide, acres treated, and size of the spray tank ("don't know" responses were generally less than 5% with a range from 0% to 7%). More subjects had difficulty recalling the amount of active ingredient applied and amount purchased with the proportion of "don't know" responses typically 10% or greater (range from 3% to 27%). There were fewer "don't know" responses regarding herbicide use in the 1980s than during the 1960s.

As part of the effort to evaluate the reliability of the responses provided we asked the interviewers and the subjects to rate their confidence in the answers provided on various topics (table 4). Farmers felt they could report on most of the areas addressed fairly accurately or very accurately. Their confidence was lower regarding the accuracy of pesticide use in the 1960s (47% fairly or very accurate) than in the 1980s (89% fairly or very accurate). They also indicated that the total number of hours they worked with herbicides each year was difficult to recall. Interviewers indicated they were fairly confident of the information provided by 90% of the subjects.

Discussion

Interviews with farmers have long been used to obtain information on agricultural chemical use for agricultural and health purposes. The U.S. Department of Agricultural (USDA) has used interviews with farmers to obtain information on acres of specific crops or livestock being treated with pesticides, chemical applied, amount applied, form of the purchased concentrate, application method, and the target pest (Andrilenas, 1974; Eichers et al., 1978; Duffy, 1983). These surveys typically seek information on pesticide use during the most recent calendar year and farmers can provide such information quite accurately. Epidemiologic studies of chronic diseases have also used interviews to obtain information about farmer's use of pesticides (Hoar al., 1986; Brown et al., 1990; Zahm et al., 1992; Cantor et al., 1992), but these surveys seek information remote in time (often for the subject's

Table 3. Percent* and (number) of "don't know" responses to detailed questions on herbicide application in the 1960s and 1980s

	1960s			1980s		
Pesticide Use Factor	Atrazine (N = 64)	Alachlor (N = 27)	2,4-D (N = 102)	Atrazine (N = 138)	Alachlor (N = 138)	2,4-D (N = 171)
Used	<1 (1)	0 (0)	0 (0)	0 (0)	<1 (1)	0 (0)
Amount active ingredient used	13 (9)	20 (6)	19 (20)	7 (10)	16 (23)	15 (25)
Amount purchased	17 (12)	27 (8)	10 (11)	6 (8)	11 (16)	3 (5)
Container size	12 (8)	0 (0)	1 (1)	<1 (1)	<1 (1)	<1 (1)
Total acres treated	4 (3)	7 (2)	1 (1)	<1 (1)	<1 (1)	3 (5)
Acres treated per hour	7 (5)	7 (2)	3 (3)	2 (3)	0 (0)	6 (10)
Size of sprayer tank	4 (3)	3 (1)	1 (1)	0 (0)	0 (0)	0 (0)

*Percent of subjects reporting use of the chemical being evaluated.

Table 4. Interviewer and farmer assessment of the quality of responses provided during the interview

Questionnaire Section	Very Accurate	Fairly Accurate	Not Too Accurate	Best Guess	Not Applicable
Farmers					
Year of birth and education	100	0	0	0	0
Current crop production	68	23	0	1	18
Historical crop production	51	46	2	2	0
Pesticides used in 1960s	11	36	14	2	37
Pesticides used in 1980s	30	59	3	0	8
Crop insecticides used in 1960s	7	16	6	2	71
Crop insecticides used in 1980s	16	30	1	0	53
Livestock insecticides used in 1960s	6	15	7	1	71
Livestock insecticides used in 1980s	13	25	2	1	60
Total hours you worked with herbicides	4	67	17	10	2
Questions about spray equipment	46	41	2	2	10
Questions about pesticide spills	49	38	2	1	10
Health symptoms associated with use of pesticides	58	41	1	1	0
Frequency of washing after pesticide use	42	54	2	0	2
Overall questionnaire	17	78	3	1	1
Interviewers					
Subject's farm history	43	51	6	1	0
Overall quality of information provided	30	61	8	1	0

entire farming career). The amount of detail farmers can provide regarding pesticide activities many years in the past and the reliability and accuracy of these responses has not been carefully evaluated. Concerns about farmer's ability to recall details about work practices for years in the past may account for the absence of such detailed questions in epidemiologic investigations. Detailed information is required, however, if we are to improve exposure assessment in epidemiologic investigations (Blair et al., 1989). This methodologic study was designed to obtain data on how much detail farmers could provide about pesticide used years in the past and to evaluate the utility of different interviewing procedures.

Because the number of pesticides available for use by farmers may be quite large, investigators might prefer to use an open ended or volunteer approach to obtain information. Providing probes by reading a long list of chemicals is quite time consuming. In a volunteer approach, individuals are asked to provide the names of pesticides used without prompting from the interviewer. This technique shortens the interview because most subjects will have used only a few of the pesticides ever on the market. We found, however, that some pesticides are poorly ascertained by the volunteer approach. More commonly used pesticides were more likely to be recalled without a probe. We found the correlation between proportion only reported by probing and total number of farmers reporting use was 0.56. Over 40% of the farmers reporting use of chloramben, bentazon, atrazine/metalochlor, acifluorfen, bromozynil, fluazifop-butyl, sethoxydim, propachlor, glyphosate, aldrin, chlordane, heptachlor, and malathion did not indicate they used these chemicals in the volunteer portion of the interview. Thus, a sizable fraction of users responded positively only after a probe by the interviewer. An under-ascertainment of this magnitude would seriously diminish study power and would bias estimates of relative risk toward the null because a sizable fraction of the individuals classified as unexposed would, in fact, be exposed. In such situations with so much misclassification, the comparison is to a large extent between exposed and exposed, instead of exposed and unexposed. Obviously this is undesirable. It would appear,

therefore, that for some pesticides s
of interest in order to identify r
proportion of farmers who voluntee
Most farmers in this survey rep
year, which is consistent with othe
1993). The reported number of days
was volunteered or required a prob
specific pesticides is not substantiall
In Iowa, corn and soybeans a
frequently with insecticides. For ex
soybeans in Iowa were treated with
insecticides (Hartzler and Winterst
that most crop pesticides were used
Most farmers provided informa
acre, amount purchased, acres tre
alachlor, and 2,4-D. The amount
considerably from that reported in
Service (Hartzler and Wintersteen
ingredient reported was 6.6 for atra
in our study) and 11.4 for alachlo
mean of 6.2 in our study). Altho
ingredient per acre by crop, the rate
on corn and soybeans in the Exten
atrazine application rates for our stu
substantial, given that atrazine is use
obtain information on amount of ac
The proportion of farmers who c
questions regarding amount of pesti
applied. Although we have no me
questions, it seems reasonable that th
these questions probably contains r
"don't know" responses. This is gen
where more detailed questions
(Pickle et al., 1983). This apparent l
use does not necessarily indicate, how
critical issue is the amount of exp
surrogate, even if ascertained w
misclassification than a direct indicat
Information provided by farmers
Our farmers reported an increase in
the 1960s to the 1980s. This is
(Reimund et al., 1986). The amount o
decreased between the 1960s and 19
application rates reported by Hartzler
Farmers indicated that they were
information on pesticide use. They w
used many years in the past and the
suggests that trying to obtain hours o
more useful information than days of
interviews, interviewers believed t
information on agricultural activities.

ment of the quality of responses provided
ne interview

	Very Accurate	Fairly Accurate	Not Too Accurate	Best Guess	Not Applicable
	100	0	0	0	0
	68	23	0	1	18
	51	46	2	2	0
	11	36	14	2	37
	30	59	3	0	8
	7	16	6	2	71
	16	30	1	0	53
	6	15	7	1	71
	13	25	2	1	60
	4	67	17	10	2
	46	41	2	2	10
	49	38	2	1	10
	58	41	1	1	0
	42	54	2	0	2
	17	78	3	1	1
	43	51	6	1	0
	30	61	8	1	0

il farmers can provide regarding pesticide
eliability and accuracy of these responses
ns about farmer's ability to recall details
st may account for the absence of such
gations. Detailed information is required,
ssessment in epidemiologic investigations
dy was designed to obtain data on how
pesticide used years in the past and to
procedures.
le for use by farmers may be quite large,
ended or volunteer approach to obtain
a long list of chemicals is quite time
duals are asked to provide the names of
interviewer. This technique shortens the
ised only a few of the pesticides ever on
pesticides are poorly ascertained by the
pesticides were more likely to be recalled
n between proportion only reported by
orting use was 0.56. Over 40% of the
azon, atrazine/metalochlor, acifluorfen,
opachlor, glyphosate, aldrin, chlordane,
ate they used these chemicals in the
a sizable fraction of users responded
iewer. An under-ascertainment of this
ly power and would bias estimates of
e fraction of the individuals classified as
. In such situations with so much
e extent between exposed and exposed,
sly this is undesirable. It would appear,

therefore, that for some pesticides subjects must be directly asked about the chemical of interest in order to identify many users and to avoid under reporting. The proportion of farmers who volunteered use of various pesticides varied little by age.

Most farmers in this survey reported using various pesticides only a few days per year, which is consistent with other surveys (Blair and Zahm, 1993; Johnson et al., 1993). The reported number of days of use was similar whether the use of the pesticide was volunteered or required a probe. This suggests that the details regarding use of specific pesticides is not substantially affected by the interview method.

In Iowa, corn and soybeans are routinely treated with herbicides, but less frequently with insecticides. For example, in 1990 over 95% of the acres of corn and soybeans in Iowa were treated with herbicides, but only about 35% of the corn with insecticides (Hartzler and Wintersteen, 1991). Farmers in our survey also reported that most crop pesticides were used on corn or soybeans.

Most farmers provided information on amount of active ingredient applied per acre, amount purchased, acres treated, and acres treated per hour for atrazine, alachlor, and 2,4-D. The amount of active ingredient reported, however, differed considerably from that reported in a survey by the Iowa State University Extension Service (Hartzler and Wintersteen, 1991). In 1979 the pounds per acre of active ingredient reported was 6.6 for atrazine on corn (compared to a mean of 1.8 in 1980 in our study) and 11.4 for alachlor on corn and 0.5 on soybeans (compared to a mean of 6.2 in our study). Although we did not ask for the amount of active ingredient per acre by crop, the rate reported here (i.e., 6.2) is between that reported on corn and soybeans in the Extension Service Survey. The difference for reported atrazine application rates for our study and the Extension Service Survey, however, is substantial, given that atrazine is used almost entirely on corn. Obviously if one is to obtain information on amount of active ingredient per acre it must be crop specific. The proportion of farmers who could not provide responses was greatest for questions regarding amount of pesticide purchased and amount of active ingredient applied. Although we have no measure of validity for responses to any of the questions, it seems reasonable that the information from farmers who did respond to these questions probably contains more inaccuracies than for questions with few "don't know" responses. This is generally consistent with other survey information where more detailed questions usually have lower reliability and validity (Pickle et al., 1983). This apparent lower quality of reporting on details of pesticide use does not necessarily indicate, however, that the information is without value. The critical issue is the amount of exposure misclassification introduced. A poor surrogate, even if ascertained with great validity, could introduce more misclassification than a direct indicator measured less accurately.

Information provided by farmers in our survey is consistent with other surveys. Our farmers reported an increase in the number of acres treated with atrazine from the 1960s to the 1980s. This is consistent with the changes in farm size (Reimund et al., 1986). The amount of pesticide applied per acre reported by farmers decreased between the 1960s and 1980s, which is consistent with the reduction in application rates reported by Hartzler and Wintersteen (1991).

Farmers indicated that they were reasonably confident that they could provide information on pesticide use. They were less confident about the specific pesticides used many years in the past and the total hours they worked with pesticides. This suggests that trying to obtain hours of use in the distant past may not provide much more useful information than days of use. Based on observations made during the interviews, interviewers believed that farmers could provide fairly accurate information on agricultural activities.

References

Andrilenas, P. A. 1974. Farmers' use of pesticides in 1971—Quantities. Agricultural Economic Report No. 252. Washington, D.C.: U.S. Department of Agriculture, Economic Research Service.

Blair, A., S. H. Zahm, K. P. Cantor and P. A. Stewart. 1989. Estimating exposure to pesticides in epidemiological studies of cancer. In *Biological Monitoring for Pesticide Exposure*. eds. R. G. M. Wang, C. A. Franklin, R. C. Honeycutt and J. C. Reinert, 38-46. ACS Symp Ser 382. Washington, D.C.: American Chemical Society.

Blair, A. and S. H. Zahm. 1993. Patterns of pesticide use among farmers: Implications for epidemiologic research. *Epidemiol.* 4:55-62.

Blair, A., B. Kross, P. A. Stewart, L. Ogilivie, R. Falk, W. Popendorf, M. H. Ward and S. H. Zahm. 1995. Comparability of information on pesticide use obtained from farmers and their proxy respondents. *J. Agric. Safety Health* 1:165-176.

Brown, L. M., A. Blair, R. Gibson, G. C. Everett, K. P. Cantor, L. M. Schuman, L. F. Burmeister, S. F. Van Lier and F. Dick. 1990. Pesticide exposures and other agricultural risk factors for leukemia among men in Iowa and Minnesota. *Cancer Res.* 50:6585-6591.

Cantor, K. P., A. Blair, G. Everett, R. Gibson, L. F. Burmeister, L. M. Brown, L. Schuman and F. R. Dick. 1992. Pesticides and other agricultural risk factors for non-Hodgkin's lymphoma among men in Iowa and Minnesota. *Cancer Res.* 52:2447-2455.

Duffy, M. 1983. Pesticide use and practices, 1982. Agric Informat Bull No 462. Agric Information Bull. Washington, D.C.: U.S. Department of Agriculture, Economic Research Service.

Eichers, T. R., P. A. Andrilenas and T. W. Anderson. 1978. Farmers' use of pesticides in 1976. Agricultural Economic Report No. 418. Washington, D.C.: U.S. Department of Agriculture, Economics, Statistics, and Cooperatives Service.

Hardell, L. and A. Sandstrom. 1979. Case-control study: Soft tissue sarcomas and exposure to phenoxy acetic acids or chlorophenols. *Br. J. Cancer* 39:711-717.

Hartzler, R. and W. Wintersteen. 1991. A survey of pesticides used in Iowa crop production in 1990. Ames, Iowa: Iowa State University, University Extension.

Hoar, S. K., A. Blair, F. F. Holmes, C. D. Boysen, R. J. Robel, R. N. Hoover and J. F. Fraumeni Jr. 1986. Agricultural herbicide use and risk of lymphoma and soft tissue sarcoma. *JAMA* 256:1141-1147.

Johnson, R. A., J. S. Mandel, R. W. Gibson, J. H. Mandel, A. P. Bender, P. D. Gunderson and C. M. Renier. 1993. Data on prior pesticide use collected from self- and proxy respondents. *Epidemiol.* 4:157-164.

Kross, B. C., G. R. Hallberg, R. Bruner, K. Cherryhomes and J. K. Johnson. 1993. The nitrate contamination of private well water in Iowa. *Am. J. Public Health* 83:270-272.

Pearce, N. E., A. H. Smith, J. K. Howard, R. A. Sheppard, H. J. Giles and C. A. Teague. 1986 Non-Hodgkin's lymphoma and exposure to phenoxy herbicides, chlorophenols, fencing work, and meat works employment: A case-control study. *British J. Ind. Med.* 43:75-83.

Pickle, L. W., L. M. Brown and W. J. Blot. 1983. Information available from surrogate respondents in case-control interview studies. *Am. J. Epidemiol.* 118:99-108.

Reimund, D. A., N. L. Brooks and P. D. Velde. 1986. The U.S. farm sector in the mid-1980s. Agricultural Economic Report No. 548. Washington, D.C.: U.S. Department of Agriculture, Economic Research Service.

Zahm, S. H., D. D. Weisenburger, P. A. Babbitt, R. C. Saal, J. B. Vaught, K. P. Cantor and A. Blair. 1990. A case-control of non-Hodgkin's lymphoma and the herbicide 2,4-dichlorophenoxyacetic acid (2,4-D) in eastern Nebraska. *Epidemiol.* 1:349-356.

Tractor Fat
on New Z

J. D. Langley, J. Clarke, S.

A

The aim of the research was to descr
Zealand farms which resulted in death
identified from three independent data
were selected from national hospital inp

There were 51 deaths, an average of
rural residents per year. Only 47% of the
in the 60+ age group had the highest n
incidents requiring inpatient treatment,
22 per 100,000 rural residents per year.
gender specific rate. At least 23% of
occurred to persons whose primary occu

When specific events were examine
significant decline in non fatal overturn
to other types of crash increasing over
of fatalities and non-fatal injury, the n
the majority of tractor incidents did not

Efforts to reduce mortality and mor
facilitated by: an enhancement of natio
specific classes of events with priority
the elderly, children, and those whose
addition, existing and proposed legis
comprehensively addresses protection fo

Keywords. Farm, Injury, Mortality, M

Farming has been identified by th
Compensation Insurance Corpo
of injury. It is also an industry fo
high. In 1992 work claims paid to the
alone cost the ACC a total of $NZ4

The authors are John D. Langley, Director
Biostatistician of the Injury Prevention Resear
Stephen Marshall, Biostatistician of the Injury P
at Chapel Hill; and Colin Cryer, Statistician, S
Kent, England.

Corresponding author: John D. Langley, PhI
of Otago, PO Box 913, Dunedin, New Zeala
<jlangley@gandalf.otago.ac.nz>.