

Use of Protective Equipment Among California Farmers

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Background Agriculture is a hazardous industry associated with many occupational injuries and illnesses. We describe California farmers' self-reported exposure to five agricultural hazards and their use of protective equipment.

Methods A telephone survey of 1,947 California farmers recorded information on occupational exposure, health outcomes and use of protective equipment to lessen risk from exposure to dust, sun, noise, pesticides and tractors.

Results Over 93% of respondents reported using personal protection around pesticides; however, fewer than 1/3 used consistent protection against other hazards. Younger age and male sex were associated with better use of protection from dust, noise, pesticide and tractors, but negatively associated with sun protection. There was no consistent relationship of protective behaviors with cigarette smoking, living on the farm, marital status, or time in non-administrative farmwork. Risk perception was strongly associated with behavior; farmers concerned about specific health problems were much more likely to use protective equipment.

Conclusions Some farmer characteristics are associated with more safe behaviors, but efforts to encourage protective behaviors on farms should be broadly based in view of a lack of a single risk-taking profile among California farmers. *Am. J. Ind. Med.* 42:455–464, 2002. © 2002 Wiley-Liss, Inc.

KEY WORDS: farmer; farm operator; risk; protection; protective equipment; sun; dust; noise; pesticide; tractor; hazard; behavior

INTRODUCTION

Agriculture is an extremely hazardous industry associated with a large number of occupational injuries and chronic illnesses [Schenker, 1996]. In 1999, the National Safety Council reported that agriculture had the second highest occupational death rate in the US (after mining/quarrying),

averaging 22.1 deaths per 100,000 workers [National Safety Council, 1999]. In addition to occupational injuries and fatalities, there is a wide range of chronic diseases that result from agricultural exposures, including musculoskeletal, respiratory, dermatologic and reproductive disorders.

Five of the major health hazards faced by farmers and farmworkers are: agricultural dust, sun exposure, noise, pesticides, and powered farming equipment. The health problems caused by these hazards in the agricultural workplace have been well documented [Dosman and Cockcroft, 1989]. The organic and inorganic components of dust have been shown to contribute to respiratory symptoms and disease among agricultural workers [Schenker, 1998]. Sun exposure may be responsible for observed increases in melanoma of the skin and lip cancer incidence in farmers [Stark et al., 1990]. Hearing loss is also increased in farmers—studies suggest that approximately 25% of male farmers have a communication handicap due to hearing loss by age 30, rising to 50%

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by age 50 [Karlovich et al., 1988]. Pesticide-induced illness has been well documented, and has resulted in both morbidity and mortality among agricultural populations [Schenker et al., 1998]. Tractors and other powered farming equipment are the leading cause of traumatic deaths. The National Safety Council reported in 1999 that 37% of all farm work deaths resulted from tractor-related events [Council, 1999].

Although California farms only account for 3% of the nation's farmland, it is the leading agricultural state based on production. Over 250 different crops and livestock products are raised in California, emphasizing the diversity of farming operations and practices. Agricultural practices in California are different from other parts of the country, and prevention efforts need to be targeted to the state's unique workforce and agricultural practices. However, most data on agricultural health and safety hazards come from other parts of the country.

We have established a representative cohort of California farm operators for assessment of occupational exposures and multiple health outcomes. A cross-sectional survey of 1,947 California farmers and farm operators was completed in 1993. Information was recorded by telephone interview on occupational exposures, health outcomes and personal use of protective equipment. Questions on personal protection focused on reducing potentially hazardous exposure to dust, sun, noise, pesticides and powered farming equipment. Our objective was to determine the self-reported exposure of farmers to these potential workplace hazards, the prevalence of protective equipment use, and personal characteristics associated with more consistent use of protective equipment.

METHODS

Study Population

The study population was selected in 1992 from the California Agricultural Statistics Service (CASS) list frame of approximately 58,000 farms in California. A farm was defined by CASS as a location that produced, or normally would have produced, at least \$1,000 in income from agriculturally related products during the previous year. Our study was directed towards the primary operator of the farm, defined as the individual responsible for making the day-to-day decisions on the farm.

Of the 4,500 farm operators systematically selected from the list frame, 3,773 were able to be contacted by telephone for an interview. Of the 2,422 farm operators contacted who were eligible for the study, 1,947 (80.4%) completed an interview.

Data Collection

A Computer-Assisted Telephone Interview (CATI) was administered by experienced, trained interviewers to all

eligible farm operators. Information was recorded on demographics, farm characteristics, occupational exposures and specific health outcomes. Standardized questions were included from the National Health Interview Survey (NHIS) and the National Health and Nutrition Epidemiological Survey (NHANES III). Questions on protective equipment use focused on five exposures that pose potential occupational hazards for farmers: dust, sun exposure, noise, pesticides, and powered farming equipment (including driving a tractor).

Study Variables

For each of the five hazards listed above, the respondent was asked to approximate the amount of farming time she/he was exposed to the hazard within the last 12 months; and to rate how often specific types of protective equipment were used while exposed.

Protective equipment itemized included: scarf over nose and mouth, disposable dust mask or cartridge respirator for dust exposure; sunscreen, hat with sun brim or long-sleeved shirt for sun exposure; earplugs/earmuffs for noise; and gloves, protective clothing, cartridge or other respirator, face shield or goggles, or rubber boots for pesticide exposure. It was recognized that these equipment provided varying degrees of protection, and that for some types of equipment, use may have represented more "concern about reducing exposure" than actual protection.

Respondents were asked whether they used each type of protection rarely or never, less than half the time, about half the time, more than half the time, or nearly always. Subjects were also asked whether or not their tractors were equipped with rollover protection, an enclosed cab, shielded power take-off, and whether they routinely used a seatbelt while operating the tractor.

Data Analysis

Statistical analysis was conducted using the Statistical Analysis System (SAS Institute, Cary, NC) software package version 6.12.

We attempted to determine what characteristics were associated with farmers who more consistently used protective equipment versus those who did not. For each hazard we defined a group with 'better' protection habits among farmers who spent a certain minimum of time exposed to the hazard. Although we do not know what level and combination of protective equipment use is truly adequate for substantially reducing risk, these groupings gave us the statistical power to examine characteristics of farmers who used protection more consistently. The definitions used were as follows:

Dust

We decided that the use of either a disposable dust mask or a cartridge respirator for half the time or more comprised ‘better’ use. For farmers who worked in dusty conditions at least 5% of their farming time, 32% (n = 426) fell into this category.

Sun

‘Better’ protection was defined as use of both sunscreen and long-sleeved shirt for more than half the time. For the farmers who worked in the sun at least 5% of the time, 6% (n = 116) fell into this category.

Noise

We only asked about one type of hearing protection (earplugs/earmuffs), so ‘better’ protection was defined as one type of protection for half the time or more. For the farmers who worked around noise at least 5% of the time, 30% (n = 423) fell into this category.

Pesticides

‘Better’ protection meant using at least three types of protection for more than half the time when using pesticides (gloves, protective clothing, cartridge or other respirator, face shield or goggles, or rubber boots), for any farmer who used pesticides at all. There were 57% (n = 508) of the farmers who worked with pesticides in the previous year who used ‘better’ protection.

Tractors

‘Better’ protection was defined as using at least two of: routine seatbelt use, rollover protection, enclosed cab or shielded power take-off on the primary tractor. There were 34% (n = 487) of the farmers who used tractors at least 5 hr during the year who fell into this category.

A small number of variables relating to personal characteristics that we hypothesized may have an association with use of adequate protection were investigated:

- Age,
- Sex,
- Lives on/off the farm,
- Cigarette smoking,
- Marital status,
- Percent time working at non-administrative farm tasks,
- Percent time spent around the hazardous exposure,
- Belief that farming is safer than other professions,
- Concern about injuries,
- Concern about skin problems,

- Concern about cancer,
- Concern about respiratory problems,
- Concern about hearing loss.

The association between size and type of farming operation, exposure to these hazards and use of protective equipment has already been examined in this cohort [Farrar et al., 1995].

RESULTS

Unlike farm workers in California, who are predominantly Hispanic, young, and poor, the farm operators were overwhelmingly white, older, and well educated (Table I).

TABLE I. Demographic Characteristics of Study Population, California Farmer Cohort

Total study sample	1,947
Average age	54.4 years (SD 13.4 years; range 21 – 90)
Sex	90% male
Median salary	\$50,000 – 100,000 (US\$)
Live on farm	72%
Ownership of farm	72.5% owner/operators 4.9% operator 7.3% hired manager 13.4% co-owner 1.9% other
Race	87.7% white 0.2% black 0.8% American Indian, Eskimo or Aleut 4.7% Asian or Pacific Islander 6.5% other
Ethnicity	6.2% Hispanic
Education	9.5% less than 12 years 27.3% high school graduate 62.9% more than high school
Smoking status	12% current smokers 33% ex-smokers 56% non-smokers
Farm	17.4% large mixed 7.7% field 45.4% fruit 13.2% livestock 3.4% nursery 12.0% small mixed 1.0% vegetables
%Time in farm activities (mean ± SD)	
Administration	21.5 ± 26.7
Field supervision of farm workers	4.5 ± 21.1
Work with livestock/poultry/fish	14.5 ± 28.1
Planting, irrigating, harvesting	34.9 ± 32.3

Our sample was representative of farm operators in demographic and farm characteristics when compared with the 1992 Census of Agriculture for California.

Tables II and III present the characteristics of farmers who were more likely to fall into the 'better' protected group for each of the five hazards. Since the designation of 'better' protection is somewhat arbitrary, it is not useful to compare the proportion (or mean) of those using adequate protection to those who don't. That is, the question is not: what is the mean age of 'better' users, compared to 'worse' users, but: who is more likely to use 'better' protection: older farmers or younger farmers? And is there a trend with increasing/decreasing age?

Dust

Farmers in our study reported that they spent an average (median) of 10% of their day in dusty conditions (inter-quartile range 1–30%) (Table IV). However, only 24.4% (n = 475) of farmers exposed to dust used a dust mask or cartridge respirator more than half the time when working around dust. Among operators working around dust more than 5% of the time (n = 1325), a disposable dust mask was worn most often (Fig. 1). A disposable dust mask was used more than half the time by 19.9% (n = 264), compared with a cartridge respirator (3.7%, n = 49). A scarf, which provides little respiratory protection, was worn more than half the time by 3.7%, n = 49).

We examined the attributes of a group of farmers having 'better' dust protection habits to ascertain the characteristics of these farmers (Table V). Better dust protection was defined as using a disposable dust mask or cartridge respiratory half the time or more. Younger farmers were significantly more likely to use 'better' protection from dust—39% of farmers under 40 used 'better' protection, vs. 28% of those over 70 ($P = 0.02$). Males ($P = 0.01$) and those who smoked fewer cigarettes ($P = 0.005$) were also significantly more likely to use 'better' protection. Increased concern about skin problems and about respiratory problems were both significantly associated with use of better dust protection in univariate models (Table III). However, there was a strong correlation ($r^2 = 0.48$) between these two factors.

In a multivariate logistic regression model, younger age, fewer cigarettes smoked per day, male sex and concern about respiratory problems remained as significant predictors of better use of protection from dust, and belief that farming is safer than other professions became statistically significant (Table V). However, the model performed poorly. The area under the ROC curve for the best models was approximately 0.64. A prediction rule based on the models would have a sensitivity and specificity simultaneously of no more than 55% each.

Sun Exposure

Farmers reported spending a great deal of their time in the sun (median = 75% of farming time, inter-quartile range 50–90%). Among farmers who spent at least five percent of their time in the sun (n = 1,833), hats with sun brims, such as baseball caps, were worn most often, with 70.3% (n = 1,289) of respondents reporting wearing hats more than half the time. Sunscreen was worn least often, with 69.4% of farmers (n = 1,270) reporting rarely/never using sunscreen. Long-sleeved shirts were worn more than half the time by only 35.7% (n = 654) of respondents. Women were much more likely than men to wear sunscreen or long-sleeved shirts, but much less likely to wear a hat. Only 116 farmers (6.0%) used both sun protection and long-sleeved shirt more than half the time. Approximately 33% of farmers (n = 655) used at least two of the three forms of sun protection for more than half the time.

In univariate models, older farmers, women, those who smoked less, were not married or living with a partner, and those who were concerned about skin problems were more likely to use protection from the sun. Farmers who felt that farming was safer than other professions were also more likely to use long sleeve shirt ($P = 0.003$) but not sunscreen ($P = 0.75$).

In a multivariate logistic regression model, all these variables remained significant except for marital status, indicating that each had an independent contribution to the overall model.

Noise

Farmers in our study reported working around noisy machinery for an average (median) of 10% of their day (inter-quartile range 2–33%). Among the 1,401 farmers who spent at least 5% of their time in noisy conditions, only 22.8% (n = 319) wore ear protection more than half the time when working around noise, and 56.3% (n = 789) reported using hearing protection rarely or never.

'Better' hearing protection was positively associated with younger age, male sex, fewer cigarettes smoked, and a higher percent of time spent in non-administrative farm jobs. Use of hearing protection increased with increased time spent around noise, increased concern about hearing loss and increased concern about injuries. In a logistic regression model, amount of time spent around noise and cigarette smoking became non-significant when all other variables were controlled for. Not surprisingly, concern about hearing loss remained the strongest predictor for use of 'better' hearing protection.

Pesticides

Only 45% (n = 885) of respondents had mixed, loaded or applied pesticides within the 12 months prior to the survey.

TABLE II. Univariate Associations Between 'Better' Use of Protective Equipment and Personal Characteristics, U.C. Davis California Farmer Cohort

	'Better' dust protection ^a		'Better' sun protection ^b		'Better' noise protection ^c		'Better' pesticide protection ^d		'Better' tractor protection ^e	
	Total n = 426		Total n = 116		Total n = 423		Total n = 508		Total n = 487	
	%	N	%	N	%	N	%	N	%	N
Age										
<40	39	91	2	5	36	88	65	112	41	97
40–54	32	158	5	35	31	164	60	204	38	202
55–69	30	137	8	50	26	127	52	148	31	151
70+	28	38	11	25	29	42	51	43	23	36
	P = 0.022		P = 0.0001		P = 0.019		P = 0.003		P = 0.001	
Sex										
Male	33	404	5	82	31	412	58	494	35	467
Female	21	22	20	34	15	11	35	14	26	20
	P = 0.013		P = 0.0001		P = 0.004		P = 0.003		P = 0.120	
Live on farm										
Yes	32	317	7	92	31	321	56	364	32	347
No	32	109	5	23	27	102	61	144	42	139
	P = 0.797		P = 0.092		P = 0.162		P = 0.198		P = 0.001	
Smoker										
Doesn't smoke	33	387	7	112	31	386	57	450	34	425
1–10 cigs/day	35	13	4	2	22	8	58	14	25	10
11–20 cigs/day	23	19	2	2	27	20	66	31	48	40
21+ cigarettes/day	16	7	0	0	15	8	44	10	26	11
	P = 0.005		P = 0.002		P = 0.007		P = 0.902		P = 0.481	
Married										
Yes	32	363	6	87	30	366	57	435	34	428
No	34	63	11	29	30	57	59	73	33	59
	P = 0.583		P = 0.001		P = 0.968		P = 0.638		P = 0.678	
Percent farming time in non-administrative work										
None	36	8	9	4	17	4	57	4	27	4
<1/3	24	10	6	6	16	9	72	18	58	22
1/3–2/3	33	52	8	16	30	51	66	65	52	77
2/3+	32	348	6	89	31	354	56	412	31	375
	P = 0.513		P = 0.887		P = 0.013		P = 0.035		P = 0.001	
Time spent around this exposure										
Low	33	375	7	42	24	131	52	153	27	51
Medium	33	29	7	25	32	126	58	233	28	39
High	26	22	6	49	35	166	65	122	36	397
	P = 0.307		P = 0.315		P = 0.001		P = 0.004		P = 0.003	

N for some variables do not equal total because of missing values.

^aFor Dust: Use of dust mask or respirator for half the time or more among farmers working around dust at least 5% of farming time.

^bFor Sun: Use of both sunscreen and long-sleeved shirt for more than half the time among farmers working in the sun at least 5% of farming time.

^cFor Noise: Use of one type of protection for half the time or more among farmers working in noisy conditions at least 5% of farming time.

^dFor Pesticides: Use of at least three types of protection for more than half the time when using pesticides, for farmers who used pesticides at all.

^eFor Tractors: Use of at least two of: routine seatbelt use, roll-over protection, enclosed cab or shielded power take-off on the primary tractor, among farmers using tractors at least 5 hr/year.

TABLE III. Univariate Associations Between 'Better' Use of Protective Equipment and Health Concerns, California Farmer Cohort

	'Better' dust protection ^a		'Better' sun protection ^b		'Better' noise protection ^c		'Better' pesticide protection ^d		'Better' Tractor protection ^e	
	Total n = 426		Total n = 116		Total n = 423		Total n = 508		Total n = 487	
	%	N	%	N	%	N	%	N	%	N
Farming safer than other professions?										
Farming is safer	34	99	8	34	32	97	58	118	32	106
About the same	33	192	5	42	29	175	60	218	33	202
More dangerous	29	129	7	38	30	140	55	266	38	170
	<i>P</i> = 0.164		<i>P</i> = 0.624		<i>P</i> = 0.827		<i>P</i> = 0.360		<i>P</i> = 0.085	
Concern about injuries										
Not concerned	25	51	Not applicable		23	46	46	60	28	64
Slightly concerned	35	73			27	57	54	68	30	65
Somewhat concerned	31	102			29	104	50	102	37	128
Very concerned	34	199			34	214	66	275	36	228
	<i>P</i> = 0.065				<i>P</i> = 0.001		<i>P</i> = 0.001		<i>P</i> = 0.006	
Concern about skin problems										
Not concerned	26	106	4	25	Not applicable		47	116	Not applicable	
Slightly concerned	31	82	4	14			56	100		
Somewhat concerned	35	127	6	29			61	153		
Very concerned	37	110	11	47			66	138		
	<i>P</i> = 0.0008		<i>P</i> = 0.0001				<i>P</i> = 0.001			
Concern about cancer										
Not concerned	Not applicable		6	45	Not applicable		47	146	Not applicable	
Slightly concerned			4	12			55	82		
Somewhat concerned			5	16			58	100		
Very concerned			9	42			71	176		
			<i>P</i> = 0.099				<i>P</i> = 0.001			
Concern about respiratory problems										
Not concerned	21	74	Not applicable		Not applicable		Not applicable		Not applicable	
Slightly concerned	25	62								
Somewhat concerned	36	135								
Very concerned	45	155								
	<i>P</i> = 0.0001									
Concern about hearing loss										
Not concerned	Not applicable		Not applicable		18	87	Not applicable		Not applicable	
Slightly concerned					24	62				
Somewhat concerned					35	121				
Very concerned					51	153				
					<i>P</i> = 0.001					

N for some variables do not equal total because of missing values.

^aFor Dust: Use dust mask or respirator for half the time or more among farmers working around dust at least 5% of farming time.

^bFor Sun: Use of both sunscreen and long-sleeved shirt for more than half the time among farmers working in the sun at least 5% of farming time.

^cFor Noise: Use of one type of protection for half the time or more among farmers working in noisy conditions at least 5% of farming time.

^dFor Pesticides: Use of at least three types of protection for more than half the time when using pesticides, for farmers who used pesticides at all.

^eFor Tractors: Use of at least two of: routine seatbelt use, roll-over protection, enclosed cab or shielded power take-off on the primary tractor, among farmers using tractors at least 5 hr/year.

TABLE IV. Percent of Farming Time Spent in Hazardous Exposures in the Previous 12 Months, California Farmer Cohort

	Median	25 th –75 th percentile
Dust	10% of farming time	1–30%
Sun	75% of farming time	50–90%
Noise	10% of farming time	2–33%
Pesticides	9 days used per year	0–8 days per year
Tractors	104 hr operated per year	0–416 hr per year

The median number of days using pesticides among users was 9 (inter-quartile range 0–8 days).

Pesticide protection use had the highest compliance rate of any hazard protection we investigated. Of the 885 farmers who used pesticides, only 59 reported rarely/never using some form of protective equipment. Gloves were most frequently used, with 74% (n = 655) using gloves more than half the time, followed by protective clothing (61.2%, n = 540), a face shield (56.6%, n = 500), rubber boots (40.4%, n = 356) and a cartridge respirator (38.3%, n = 338). Among farmers handling pesticides, there was a tendency to use protective equipment either not at all or more than half the time; few farmers reported using protective equipment only occasionally (less than half the time or half the time).

There was a positive association between the number of days spent using pesticides and the likelihood of using ‘better’ protection (defined as using three or more types of protection for more than half the time). Other factors associated with ‘better’ use of pesticide protection were younger age, male sex, increased concern about skin problems, and increased concern about cancer.

In a multivariate model, concern about cancer was most strongly predictive of use of ‘better’ pesticide protection; concern about skin problems became insignificant after controlling for other factors, and belief that farming is safer than other professions achieved statistical significance.

Tractor Driving

Farmers in our survey spent an average (median) of 104 hr/year driving up to three different tractors (inter-quartile range 0–416 hr/year). We investigated the use of protective equipment among the 1,426 farmers who drove tractors at least 5 hr/year.

Most farm operators in our study did not have roll-over protection structures (ROPS) installed on their tractors. Only 35.4% (n = 502) had ROPS on their primary tractor, and this number decreased for each additional tractor used (31.8% for second tractor, 27.6% for third tractor). The proportion of farmers reporting routine seatbelt use, enclosed cab (important for reducing dust exposure) and shielded power take-off

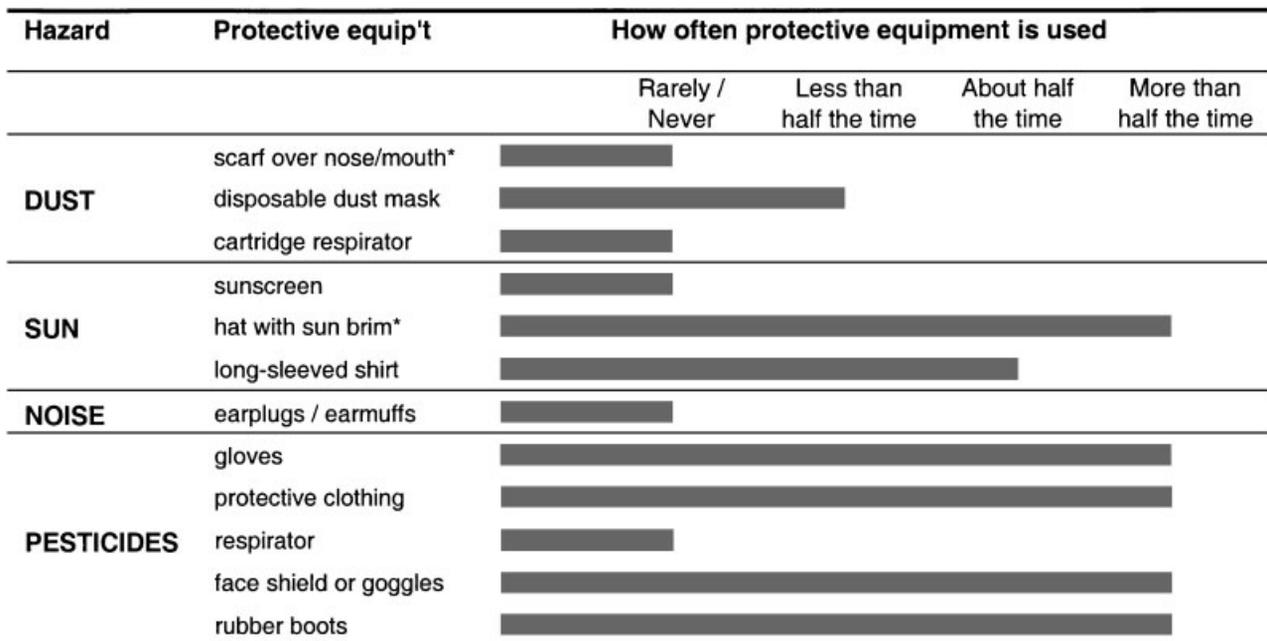


FIGURE 1. Median response for how often farm operators use protective equipment while farming, California farmer cohort. Among farmers who report at least 5% of their time exposed to dust, sun, or noise, respectively, or who spend at least 1 day/year mixing, loading, or applying pesticides. *These equipment (scarf and hat with sun brim) are recognized not to provide significant protection from hazard but are included for descriptive purposes.

TABLE V. Significant Positive or Negative Predictors ($P < 0.05$) of 'Better' Use of Protective Equipment in a Multivariate Logistic Regression Model, U.C. Davis California Farmer Cohort

	'Better' dust protection	'Better' sun protection	'Better' noise protection	'Better' pesticide protection	'Better' tractor protection
Age (older)	–	+	–	–	–
Sex (male)	+	–	+	+	
Lives on farm					+
More cigarettes smoked/day	–	–			
Married					
More time in non-administrative work			+	+	+
More time spent around this exposure					+
Thinks farming is safer than other careers	+			+	
Increased concern about injuries			+		
Increased concern about skin problems		+			
Increased concern about cancer				+	
Increased concern about resp. problems	+				
Increased concern about hearing loss			+		

also decreased for less frequently-used equipment. Seatbelt use declined from 7.2% on the first tractor to 6.2 and 5.2% for the second and third tractors; enclosed cab dropped from 15.8 to 12.6 and 11.4%; and shielded power take-off went from 73.8 to 62.7 and 54.4%.

In a univariate analysis, age was strongly associated with 'better' tractor protection, with younger farmers more likely to be in the 'better' protected group. Men were also more likely to be better-protected (35% of men vs. 26% of women), as were farmers who lived off the farm (42% vs. 32% among those who lived on the farm), as well as those farmers who spent more time on the tractor. 'Better' protection was also more likely to occur among farmers who thought farming was more dangerous than other professions, and among those who were more strongly concerned about injuries.

In a multivariate model, younger age and time spent on a tractor were most strongly predictive of 'better' protection, followed by living off the farm. Sex, concern about injuries, and perception of farming as unsafe were not significant in this multivariate model.

Correlation Between Types of Protective Equipment Use

We next analyzed whether farmers who used 'better' protection for one hazard were more likely to use 'better' protection for other hazards. There was a moderate correlation only between farmers who used protection from dust with those who used protection from noise and those who used protection from pesticides ($r^2 = 0.29$ and 0.25 respectively, $P = 0.0001$). For a farmer who used 'better' protection for noise, the odds ratio was 3.5 (95% CI: 3.2–3.8) that she/he would also use 'better' protection from dust. For a farmer

using 'better' protection from pesticides, the odds ratio was 2.9 (95% CI: 2.6–3.2) that 'better' protection from dust was used. All other relationships between hazard protections were small and not statistically significant.

DISCUSSION

Our results are consistent with other published reports on the prevalence and patterns of protective equipment use among farmers.

Viirolainen et al. [1987] examined characteristics of Finnish farmers who obtained personal dust respirators. They found that men were more likely than women, and younger farmers more likely than older farmers, to have respirators for protection from dust. In a survey of Michigan farmers, Rosenman et al. [1995] found that 40% of men and 65% of women were likely to protect their skin when outdoors. Increasing age and personal history of skin cancer increased the likelihood, and men were less likely than women to use sunscreen. Karlovich et al. [1988] found that fewer than 20% of farmers reported consistent use of personal hearing protection in farm-related duties.

There is some indication that California farmers may use pesticide protective clothing more often than farmers in other states [Avory and Coggon, 1994]. Branson and Sweeney reviewed information on pesticide application and control technology, and found that California farmers reported higher levels of pesticide protective equipment use than farmers in other parts of the country [Branson and Sweeney, 1991]. Half of California growers reported use of vinyl or rubber gloves vs. 37% in the other states surveyed. However, there is a great deal of variation reported in the literature on how often pesticide protective clothing is worn. For example,

Mandel and colleagues [Mandel et al., 1996] reported that 56% of farmers in Minnesota wore chemically resistant gloves, and only 22% wore other protective clothing 75% of the time or more when using pesticides.

Farmers in the survey who had ROPS on their primary tractors are similar to the percentage (35.4%) of farmers in other states [Kelsey et al., 1996]. Data from Iowa, Kentucky, New York and Ohio from 1992–1997 [Prevention, 1997] show that the percentage of tractors equipped with ROPS varied from a high of 40% (Iowa) to 27% (Kentucky). The proportion of tractors outfitted with ROPS varied inversely with the age of the tractors [Kelsey et al., 1994]. This agrees with the drop in ROPS, seatbelt, enclosed cab and shielded power take-off use we found for secondary and tertiary tractors, which are likely to be older models.

When we attempted to identify subgroups that used protection consistently, we found that no single demographic factor stood out as being highly associated with health protective behavior. This may be in part due to a ‘healthy farmer’ effect; it is possible that farmers who developed severe farming-related health problems early in their career dropped out of farming before they were enumerated in this cross-sectional study. Farmers who spent more time in administrative jobs also reported less protective behaviors, possibly reflective of switching to less exposed jobs by farmers with symptoms due to exposures in field work.

In the cohort, age was one of the best demographic predictors of better protective equipment use, although older age was positively associated with protection from the sun, and negatively associated with use of protection from all other hazards. Sex and smoking often showed promise as predictor variables; however, limited numbers of females (10% of the survey subjects) and smokers (~12%) made it difficult to reach any definite conclusions. Time spent around the hazard was sometimes statistically significant; however, the difference in ‘better’ protection prevalence between those in the ‘low’ group and those in the ‘high’ group was often small, indicating that this was not a very strong factor.

Concern about potential hazards or health conditions seemed to be one of the strongest indicators of whether adequate protection was used or not. This would suggest that programs to increase awareness of farm safety and occupational hazards would be an effective way of convincing farmers to use protective equipment. However, Murphy et al. [1996] pointed out that experimental data to scientifically validate the effectiveness of farm health and safety educational programs are minimal at best, and that there is currently no good evidence demonstrating that farm safety and health education promotions/activities lead to a consistent or stable reduction of risk on the farm [Mullan et al., 1996].

As mentioned earlier, we do not know what level or combination of protective equipment use is adequate to substantially reduce health problems arising from the five

hazards we investigated. We were therefore unable to look at differences between groups who used protective equipment ‘enough’ vs. ‘not enough’; instead we could only draw artificial distinctions between those farmers who used more vs. less consistent protection.

LIMITATIONS

We describe California farmers’ self-reported exposure to five potential agricultural hazards (dust, sun exposure, noise, pesticides, and tractors) and the farmers’ use of protective equipment when working around these hazards. The farmers who participated were representative of California farmers in 1993 as enumerated in the state agricultural census; however, our study used a questionnaire to obtain information on farmers’ use of protective equipment, and thus is susceptible to bias associated with self-reporting of behavior.

Another possible bias is the subjective reporting of hazardous exposures. We were unable to measure actual exposure levels in this questionnaire-based study, and perception of hazardous exposure may have varied between respondents. However, in an earlier analysis of this population we found that grouped subjective dust estimates showed a consistent increase with average measured dust levels, in particular for the inhalable dust fraction ($R^2 = 0.81$). Age, the number of years working in agriculture, education level, the presence of any respiratory symptoms, and the language of the questionnaire did not have a significant independent effect on the relationship between measured dust levels and subjective dust estimates [Nieuwenhuijsen et al., 1997]. This provides some evidence for the validity of subjectively reported exposures in this population.

Overall, there was a low prevalence of protective equipment use. Farmers were most likely to use protection from pesticide exposure: over 93% of respondents used protective equipment when working around pesticides, and most of them used the protective equipment more than half the time. However, fewer than one-third of subjects reported using protection from dust, noise, or sun exposure more than half the time. Only 35% of subjects had ROPS installed on their primary tractor, and this number decreased with each successive tractor used, as did routine seatbelt use, an enclosed cab and shielded power take-off. The low number of average hours of tractor use reported by farm owners and managers in this study may reflect that the majority of tractor driving is done by hired farmworkers. Nevertheless, physical characteristics of safer tractors (ROPS, shielded power take-offs) would still pertain to other individuals driving tractors on these farms.

Younger age and male sex were associated with better use of protection from dust, noise, pesticide, and around tractors, but were negatively associated with use of protection from the sun. There did not appear to be any consistent

relationship between use of protective equipment and variables such as smoking history, living on the farm, being married or time spent in non-administrative farm work.

There was a moderate association between better use of protective equipment and a higher amount of time spent at each hazardous farm task, with the exception of working around dust, which showed an insignificant association in the opposite direction. Protective equipment use was positively associated with risk perception. Farmers who were more concerned about specific health problems were much more likely to use protective equipment when working around the relevant hazard. We were unable to predict behavior based on the characteristics we recorded, and few farmers who used sufficient protection around one type of hazard used sufficient protection in all situations. There does not appear to be a single 'profile' of the type of farmer most likely to use protective equipment. Educational efforts to encourage protective equipment use should be broadly based in view of a lack of a single risk-taking profile derived from the type of data obtained in this study. Recent work suggests that educational and other intervention efforts may have a positive impact on protective equipment use, but more work is needed to confirm the effectiveness of such efforts [Mandel et al., 2000; Landsittel et al., 2001].

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