Nonfatal Occupational Injury Among California Farm Operators

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Abstract. *We conducted a population−based telephone survey addressing farm−work−related (FWR) injuries among California farm operators. Of 1947 participants (80.4% response), 135 farm operators reported 160 FWR injuries in the preceding year, yielding a one−year cumulative incidence for any FWR injury of 6.9% (95% CI 5.8%−8.2%), or a mean 8.2 FWR injuries per 100 farmers in the preceding year (95% CI 6.8−9.7). Multiple injury events in the same individual occurred more frequently than predicted by chance. Sprains and strains (29.4%) were the most frequently reported injury and predominantly involved the back. Overexertion represented the most frequent external cause (24.2%), followed by machinery (14.3%), falls (13.0%), and animals (12.4%). Factors associated with FWR injury included white ethnicity (OR 3.19; 95% CI 1.38−7.36), increased annual hours worked on the farm, low levels of administrative work, and increased percentage of time working with livestock. FWR injury experience of California farm operators is comparable with that reported for other agricultural populations. Above−expected frequency of multiple injuries supports involvement of personal or environmental risk factors. Preventive efforts should focus on higher−risk groups and preventing overexertion and muscle strain and injury related to machinery, falls, and animals, especially livestock.*

Keywords. *Agricultural worker, Agriculture, Farmer, Injury, Workplace accidents.*

"To own a bit of ground, to scratch it with a hoe, to plant seeds and watch their renewal of life −− this is the commonest delight of the race, the most satisfactory thing a man can do."

−−−− Charles Dudley Warner (1829−1900)

Agriculture is one of the most important industries in the U.S., employing over 3.3 million persons on the nation's 1,911,859 farms (U.S. Department of Commerce, 1999). Farming is often viewed as a quintessentially healthy lifestyle, yet it has among the highest occupational injury and mortality rates in U.S. industry (Hard et al., 2002; McCurdy and Carroll, 2000; Rautiainen and Reynolds, 2002). National and regional studies have examined injury experience on U.S. and Canadian farms (Boyle et al., 1997; Browning et al., 1998; Crawford et al., 1998; Gunderson et

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al., 1990; Hard et al., 1999; Hartling et al., 1997; Hoskin et al., 1988; Lee et al., 1996; Lewis et al., 1998; Lyman et al., 1999; Merchant, 1991; Merchant et al., 2002; Myers, 1998; Myers et al., 1999; Nordstrom et al., 1995; Pickett et al., 1995b; Pickett et al., 1999; Purschwitz and Field, 1990; Sprince et al., 2003b; Wilk, 1993; Young, 1995). Injury risk observed in these studies has ranged up to 16.6 injuries per 100 person−years.

California's agricultural industry is the largest in the U.S.; the state's 74,000 farms produce over 350 crops and lead the nation in production of over 50 commodities (U.S. Department of Commerce, 1999). In spite of the importance, size, and diversity of California's agricultural industry, the epidemiology of injury on the state's farms remains largely unexplored. In 1992, the Western Center for Agricultural Health and Safety, sponsored as part of the National Institute for Occupational Safety and Health (NIOSH) agricultural health program, initiated the U.C. Davis Farmer Health Study to address occupational health among the state's farmers. Although California and U.S. agriculture comprise other occupational groups, such as hired farm workers and migrant workers, farm operators have ultimate responsibility for the success of the operation and are often involved in the full range of agricultural activities. Thus, they are at risk for injury and other adverse occupational outcomes. We present here the results of a cross−sectional telephone survey examining nonfatal occupational injuries among California farm operators and associated risk factors.

Materials and Methods

Study Population

We randomly selected 4,500 farms from the 1993 California Agricultural Statistics Service (CASS) database of approximately 57,000 farms. A farm is defined by CASS as a location that produced or normally would have produced $1,000 or more in sales of agricultural products during the previous year. Our survey was directed to the principal farm operator (PFO) of the selected farm. The PFO was defined as the individual responsible for making the majority of the day−to−day decisions on the farm.

To assess sample representativeness, we compared respondents to refusals and to the remaining 52,943 nonselected farms for various farm characteristics included in the CASS database (total acres, total cropland acres, acres growing fruits and nuts, acres growing vegetables, and number of cattle). Some variables, such as acreage, were present in both the CASS database and the survey instrument. Comparisons of respondents to nonrespondents and refusals utilized only the CASS database, while subsequent analyses of the respondents relied on the survey instrument. We also compared respondents with the 1992 U.S.− and California−specific data from the Census of Agriculture (U.S. Department of Commerce, 1994).

Data Collection

Study candidates received an initial letter describing the study and informing them that they would be contacted by telephone. Trained interviewers contacted study candidates by telephone between January 1993 and July 1993. We made at least 12 contact attempts, and we used the telephone company's information service, the California Department of Motor Vehicles, and credit−reporting agencies to track down persons with incorrect contact information in the CASS database. Persons agreeing to participate were enrolled in accordance with requirements of the U.C. Davis Human Subjects Review Committee, which approved the study. The computer−assisted telephone interview (CATI) survey lasted approximately 40 minutes and addressed demographic characteristics, health habits, and work characteristics. Subjects were

also asked sequentially about three mutually exclusive categories of unintentional injuries occurring in the preceding 12 months: those resulting in a hospitalization for one night or longer (HP), those for which the respondent sought or should have sought medical care (SMC) but that did not result in hospitalization, and those injuries resulting in loss of work for at least one day (LWD) but that were not associated with medical care or hospitalization. A maximum of five injuries per subject for each category were recorded.

Subjects were asked to describe the circumstances of reported injuries. These included the nature of the injury and affected body part, how the injury occurred, whether the subject viewed the injury as farm−work−related (FWR), the specific commodity with which the respondent was working at time of injury, indoor vs. outdoor location, light conditions at time of injury, month of injury, days hospitalized, days of work missed, whether permanent disability resulted based on subject report, whether the subject held more than one job at the time of the injury, and number of full−time and seasonal workers employed by the operation. Full−time employees were classified as those individuals, including family members, working full−time for at least eight months per year on the farm. Farms were assigned to one of seven mutually exclusive categories reflecting the predominant commodity: field crops, vegetables, fruits, livestock, nursery, large mixed farms, and small mixed farms (Nieuwenhuijsen et al., 1996).

We evaluated potential risk factors for injury, including the subject's demographic and health characteristics, farm characteristics, and type and amount of farm work engaged in by the subject. Ethnicity was dichotomized for analysis as either white or nonwhite. Nonwhites included African−Americans, Pacific Islanders, Asians, and American Indians. Hispanics were grouped with whites.

Injury Classification

Responses for nature and extent of injury, body parts affected, and external cause were classified according to the *International Classification of Diseases*, 9th revision (ICD−9) (World Health Organization, 1977).

Statistical Analysis

Analysis involved standard statistical methods available with the SAS software library of procedures (The SAS Institute, Inc., Cary, N.C.) and STATA (College Station, Texas). Continuous variables were summarized by mean, standard deviations, median, and quartiles (Armitage et al., 2002). Categorical variables were summarized using percentages. Group comparisons for continuous variables utilized analysis of variance (for normally distributed data) or the Kruskal−Wallis test (for non−normally distributed data) (Armitage et al., 2002).

Injury risk was calculated in two ways: dichotomizing subjects as having none vs. one or more FWR injuries in the preceding year (percent of persons injured, or one−year cumulative incidence), and as mean number of FWR injuries per 100 farmers in the preceding year (thus allowing for multiple injuries in subjects). Ninety−five percent confidence intervals were based on an exact binomial interval (for one−year cumulative incidence) or Poisson distribution (for mean number of FWR injuries per 100 farmers in the preceding year) (Armitage et al., 2002).

Bivariate tabular analyses were used to identify variables for potential inclusion in a multivariate logistic model for FWR injuries. We initially looked at a generous set of variables and selected for subsequent modeling those showing crude association with injury. Variables manifesting a P−value <0.05 were retained in the model. We excluded variables that may be a consequence of injury rather than a risk factor, such as back pain.

Model fit was assessed using the Hosmer−Lemeshow test (Hosmer et al., 1991). All *P*−values represent two−sided tests.

To assess reliability of the survey data, we randomly selected 100 PFOs who completed the initial interview and completed a second brief telephone interview within 2 to 3 weeks of the original interview. Agreement between the two interviews was good, with kappa values ranging from 0.74 to 0.92 and no significant mean differences (data not shown).

Results

Sample Characteristics

We contacted 3773 (83.8%) of the 4,500 selected farm operations. Of these, 2422 (64.2%) were eligible. The major reason for ineligibility was that the individual was no longer operating a farm. Among eligible contacts, 1947 completed the telephone interview (80.4% participation rate), 34 (1.4%) partially completed the interview and were not included in subsequent analysis, and 441(18.2%) declined to participate. Of the 727 persons we were unable to contact by telephone, we received an abbreviated mailed interview from 204 (28.1%, not included in analysis). We were unable to contact the remaining 523 persons.

Based on data in the CASS database, statistically significant differences between study subjects (n = 1947) and nonselected operations (n = 52,943) were noted for median values of total acreage (55 vs. 36 acres, $P < 0.0001$, Wilcoxon test), crop acreage (40 vs. 30 acres, $P < 0.0001$, Wilcoxon test), number of cattle (122 vs. 75, $P < 0.0002$, Wilcoxon test), and acreage in fruit or nuts (22 vs. 17 acres, $P < 0.0001$, Wilcoxon test). No significant differences in these parameters were noted between study subjects and study candidates declining participation.

Respondents were predominantly middle−aged white males (table 1). Approximately one−third had at least four years of post−high−school education; 12% were current smokers. The majority of respondents lived on their farm (table 2). Nearly half of subjects derived more than half their annual income from farming activities, and over one−third spent at least 50% time performing field work. Nearly half of farms were fruit farms, and over one−quarter were small or large mixed−production operations.

Table 1. California Farmer Health Study: Selected demographic characteristics of principal farm operators.

Characteristic	Respondents	CA−1992[a]	USA−1992[a]
Total [*n* (%)]	1947 (100)	77,669 (100)	1,925,300 (100)
Mean age (years)			
Mean	54.4	55.2	53.3
Standard deviation	13.4	−−	−−
Gender [*n* (%)]			
Male	1751 (89.9)	68,016 (87.6)	1,780,144 (92.5)
Female	196 (10.1)	9653 (12.4)	145,156 (7.5)
Race/ethnicity [*n* (%)]			
White, not Hispanic	1645 (84.5)	71,872 (92.5)	1,878,722 (97.6)
Hispanic	120 (6.2)	3883 (5.0)	20,956 (1.1)
Asian/Pacific Islander	89 (4.6)	3292 (4.3)	8096 (0.4)
Other	83 (4.5)	2252 (2.9)	19,666 (1.0)
African−American	4 (0.2)	253 (0.3)	18,816 (1.0)
Not stated	6 (0.3)	−−	−−

Characteristic	Respondents	CA−1992[a]	USA−1992[a]
Education [*n* (%)]			
<12 years	186 (9.6)	−−	−−
12 years	530 (27.3)		
13−15 years	583 (30.1)		
16 years	405 (20.9)		
≥17 years	235 (12.1)		
Missing	8 (−−)		
Smoking status [*n* (%)]			
Never	1079 (55.4)	−−	−−
Former	627 (32.2)		
Current	233 (12.0)		
Not stated	8 (0.4)		

[a] Source: U.S. Department of Commerce (1994).

Table 2. California Farmer Health Study: Selected occupational and farm characteristics.

Characteristic	Respondents	CA−1992[a]	USA−1992[a]
Total [*n* (%)]	1947 (100)	77,669 (100)	1,925,300 (100)
Farm acreage [*n* (%)]			
1−9	254 (13.1)	21,485 (27.7)	166,496 (8.7)
10−49	632 (32.6)	26,089 (33.6)	387,711 (20.2)
50−179	412 (21.2)	13,883 (17.9)	584,146 (30.4)
180−499	260 (13.4)	7512 (9.7)	427,648 (22.2)
500−999	137 (7.1)	3702 (4.8)	186,387 (9.7)
>999	244 (12.6)	4998 (6.5)	172,912 (9.0)
Mean	1062	373	462
Median	60	10−49	50−179
Farm type [*n* (%)]			
Field crops	148 (7.7)	−−	−−
Vegetables	20 (1.0)		
Fruits	877 (45.4)		
Livestock	255 (13.2)		
Nursery	65 (3.4)		
Large mixed	337 (17.4)		
Small mixed	232 (12.0)		
Principle operator:			
Live on farm [*n* (%)]	1407 (72.3)	−−	−−
Principle operator: Percentage of income from farming [*n* (%)]			
<25%	659 (33.8)	−−	−−
25% to 50%	318 (16.3)		
51% to 75%	142 (7.3)		
>75%	803 (41.2)		
Not stated	25 (1.3)		
Principle operator: Percent time spent in field work [*n* (%)]			
0% time	435 (22.3)	−−	−−
1% to 49% time	769 (39.5)		
≥50% time	706 (36.3)		
Not stated	37 (1.9)		

[a] Source: U.S. Department of Commerce (1994).

Injury Experience

Farm work accounted for 160 injuries in the preceding year among 135 farm operators. Among the 135 operators reporting FWR injuries, 116 (85.9%) reported a single injury, 14 (10.4%) reported two injuries, 4 (3.0%) reported three injuries, one (0.7%) reported four injuries, and none reported more than four injuries. Four (2.5%) FWR injuries were associated with hospitalization (HP), 107 (66.9%) sought medical care (SMC), and 49 (30.6%) were lost−work−day injuries (LWD). The four injuries requiring hospitalization entailed hospital stays from one to five days (median one day). The 49 lost−work−day injuries entailed between one and 30 lost work days (median 2.5 days). Permanent disability occurred in 10 (6.2%) of FWR injuries.

One hundred twenty−five (77.6%) FWR injuries occurred outdoors, and only three (1.9%) occurred in dark or reduced−light conditions. FWR injuries showed a peak in the spring and fall.

Sprains and strained joints were the most common reported injuries, and most frequently involved the back (tables 3 and 4). Overexertion represented the most frequent external cause, comprising over one−quarter of injuries, followed by falls, machinery, and animal−related injuries (table 5).

Table 3. Nature of injury for 160 agricultural injuries among 1947 principal farm operators, California, January 1992 through July 1993.

Nature Code[a]	Description	Frequency [*n* (%)]
840−848	Sprains, strains (total)	47 (29.4)
	Back	26 (16.3)
	Knee or leg	6 (3.7)
	Other body part	1 (0.6)
	Ankle or foot	8 (5.0)
	Shoulder or upper limb	6 (3.7)
870−884,	Open wound (total)	19 (11.8)
890−893	Hand and finger	11 (6.8)
	Head	4 (2.5)
	Knee, leg, or ankle	2 (1.2)
	Other	2 (1.2)
807−828	Fractures (total)	17 (10.6)
	Rib, sternum, larynx, or trachea	6 (3.7)
	Ankle or foot	5 (3.1)
	Upper limb	4 (2.5)
	Multiple	2 (1.2)
916, 920−924	Contusions and superficial injuries (total)	11 (6.8)
	Trunk	3 (1.9)
	Eye and adnexa	1 (0.6)
	Upper limb	3 (1.9)
	Lower limb	3 (1.9)
	Superficial injuries	1 (0.6)
831, 836, 839	Dislocations (total)	4 (2.5)
	Shoulder	2 (1.2)
	Knee	1 (0.6)
	Other	1 (0.6)
885, 886	Traumatic amputations, thumb or fingers	3 (1.9)
930	Foreign body in eye	5 (3.1)

Nature Code[a]	Description	Frequency [*n* (%)]
355.9, 956	Nerve injuries	4 (2.5)
940–949	Burns	4 (2.5)
989	Toxic effects	2 (1.2)
722, 724	Intervertebral disk and other back disorders	5 (3.1)
854	Intracranial injury without skull fracture	2 (1.2)
927–928	Crush injury	6 (3.7)
959	Other and unspecified injuries	28 (17.4)
––	Other	3 (1.9)
	Total	160 (100)

[a] Source: World Health Organization (1977).

Table 4. Body part for 160 agricultural injuries among 136 principal farm operators, California, January 1992 through July 1993.

Body Part Code[a]	Description	Frequency [*n* (%)]
100–198	Head (total)	14 (8.8)
	Eye	8 (5.0)
	Head, multiple sites	1 (0.6)
	Jaw	1 (0.6)
	Other	4 (2.4)
200	Neck	3 (1.9)
410–498	Trunk (total)	62 (38.8)
	Back	45 (28.1)
	Shoulder	7 (4.4)
	Chest	8 (5.0)
	Trunk, multiple sites	2 (1.3)
300–340	Upper extremities (total)	40 (25.0)
	Finger	21 (13.1)
	Hand, except finger	10 (6.3)
	Forearm	5 (3.1)
	Upper arm	1 (0.6)
	Elbow	3 (1.9)
510–540	Lower extremities (total)	34 (21.3)
	Foot	8 (5.0)
	Ankle	9 (5.6)
	Knee	8 (5.0)
	Leg, other	9 (5.6)
700, 800	Multiple and System	7 (4.4)
	Total	160 (100)

[a] Source: U.S. Department of Labor (1987).

Table 5. External cause for 160 agricultural injuries among 1947 principal farm operators, California, January 1992 through July 1993.

E Code[a]	Description	Frequency [*n* (%)]
E927	Overexertion and strenuous movements	39 (24.2)
E919	Machinery (total)	23 (14.3)
	Agricultural machinery	11 (6.8)
	Nonagricultural machinery	12 (7.5)
E880−888	Accidental falls (total)	21 (13.0)
	Fall on same level	8 (5.0)
	Fall into hole	7 (4.3)
	Fall from ladder, scaffold, stairs, or steps	4 (2.5)
	Fall from one level to another	2 (1.2)
E828, 906	Injury from animal	20 (12.4)
E916−918	Striking or struck by objects or persons (total)	12 (7.5)
	Struck by object or person	9 (5.6)
	Struck by falling object	3 (1.9)
E920	Cutting or piercing instrument or object	12 (7.5)
E810−829	Motor vehicle accidents (total)	6 (3.7)
	Traffic	3 (1.9)
	Nontraffic	3 (1.9)
E905	Venomous animal or plant	2 (1.2)
E924	Hot, caustic, or corrosive object	2 (1.2)
E900	Excessive heat	1 (0.6)
E925	Electric current	1 (0.6)
E928	Other	11 (6.8)
−−	No external cause	10 (6.2)
	Total	160 (100)

[a] Source: World Health Organization (1977).

Injury Incidence and Correlates of Risk

The one−year cumulative incidence for FWR injuries was 6.9% (95% CI 5.8%−8.2%) and a mean 8.2 injuries per 100 farmers in the preceding year (95% CI 6.8−9.7). Based on this observed overall mean, a Poisson distribution predicted fewer cases of multiple injury (i.e., more than one injury event in the same individual) than were observed (19 observed vs. 6.2 expected, $p < 0.01$). Unadjusted odds ratios for correlates of injury are shown in table 6.

Factors independently associated with elevated FWR injury risk based on multivariate logistic regression modeling were decreased age, white ethnicity, increased hours worked on the farm in the preceding year, increased percent of time worked with livestock in the last 12 months, and low levels of administrative work (table 7). White ethnicity had the strongest association with work injury, comparable to that for the highest category of yearly work hours on the farm.

Table 6. California Farmer Health Study: Unadjusted odds ratios for potential injury covariates.

Covariates	FWR Injury (*n*)	Non−FWR Injury (*n*)	OR (95% CI)
Personal Characteristics: Demographic and Health History			
Age (years)			
≥65	24	489	1.00 (referent level)
45−64	62	856	1.48 (0.91−2.40)
19−44	49	464	2.15 (1.30−3.56)
Ethnicity			
Nonwhite	6	237	1.00 (referent level)
White	129	1575	3.24 (1.41−7.42)
Sex			
Male	121	1630	1.00 (referent level)
Female	14	182	1.04 (0.58−1.84)
Family annual income (U.S. $)			
<$25,000	12	191	1.00 (referent level)
$25 to $49,000	53	490	1.72 (0.90−3.29)
$50,000 to $99,000	34	601	0.90 (0.46−1.77)
>$100,000	31	483	1.02 (0.51−2.03)
Drink alcohol			
No	20	419	1.00 (referent level)
Yes	114	1384	1.73 (1.06−2.81)
Drinks per year (*n*)			
0	20	419	1.00 (referent level)
1−24	33	472	1.47 (0.83−2.59)
25−150	37	391	1.98 (1.13−3.48)
≥151	44	521	1.77 (1.03−3.05)
Wear a hearing aid			
No	131	1692	1.00 (referent level)
Yes	4	118	0.44 (0.16−1.21)
Limited in your farm work due to health condition			
No	112	1572	1.00 (referent level)
Yes	23	239	1.35 (0.85−2.16)
Have back pain every day for a week or more			
No	70	1326	1.00 (referent level)
Yes	65	486	2.53 (1.78−3.61)
Personal Characteristics: Farmwork−related			
Owner			
Yes	95	1313	1.00 (referent level)
No	40	499	1.11 (0.76−1.63)
Live on farm			
No	30	508	1.00 (referent level)
Yes	105	1302	1.37 (0.90−2.08)
Hours farmed last year (h)[a]			
1−480	13	392	1.00 (referent level)
481−1440	42	507	2.50 (1.32−4.72)
1441−3500	66	756	2.63 (1.43−4.83)
>3500	11	88	3.77 (1.63−8.69)

Covariates	FWR Injury (*n*)	Non−FWR Injury (*n*)	OR (95% CI)
Any non farm employment			
No	95	1206	1.00 (referent level)
Yes	39	605	0.82 (0.56−1.20)
Raise livestock			
No	66	1210	1.00 (referent level)
Yes	69	602	2.10 (1.48−2.99)
Percent time working with livestock (%)			
0	69	1259	1.00 (referent level)
1−50	37	352	1.92 (1.27−2.91)
51−100	29	201	2.63 (1.66−4.17)
Percent time working outdoors (%)			
0	3	72	1.00 (referent level)
1−25	12	258	1.17 (0.31−4.06)
26−75	53	676	1.88 (0.57−6.17)
76−100	67	806	2.00 (0.61−6.50)
Percent time administrative farm work (%)			
0−10	92	1076	1.00 (referent level)
11−50	36	527	0.80 (0.54−1.19)
>50	7	209	0.39 (0.18−0.86)
Number of hours on tractor last year (h)			
0	23	487	1.00 (referent level)
1−120	71	826	1.82 (1.12−2.95)
121−425	28	368	1.61 (0.91−2.84)
>425	13	131	2.10 (1.04−4.26)
Perception of farming			
Safer	27	442	1.00 (referent level)
About the same	55	787	1.14 (0.71−1.84)
More dangerous	51	551	1.52 (0.94−2.46)
Farm Characteristics			
Primary farm type			
Nursery	0	65	−−
Fruit	46	831	1.00 (referent level)
Small mixed	18	214	1.52 (0.86−2.67)
Field crop	11	137	1.45 (0.73−2.87)
Large mixed	31	306	1.83 (1.14−2.94)
Livestock	27	228	2.14 (1.30−3.52)
Vegetable crops	2	18	2.01 (0.45−8.91)
Farm classification			
Not a livestock farm	108	1584	1.00 (referent level)
A livestock farm	27	228	1.74 (1.11−2.71)
Grow vegetables			
No	103	1,549	1.00 (referent level)
Yes	32	263	1.83 (1.21−2.78)

Covariates	FWR Injury (*n*)	Non−FWR Injury (*n*)	OR (95% CI)
Acres of vegetables (acres)			
0	103	1549	1.00 (referent level)
1−30	27	197	2.06 (1.32−3.23)
>30	5	66	1.14 (0.45−2.89)
Grow field crops			
No	94	1348	1.00 (referent level)
Yes	41	464	1.27 (0.87−1.86)
Field crop acreage (acres)			
0	94	1348	1.00 (referent level)
1−100	17	194	1.26 (0.73−2.15)
101−1500	22	246	1.28 (0.79−2.08)
>1500	2	24	1.20 (0.28−5.13)
Grow fruits, nuts, or berries			
No	69	668	1.00 (referent level)
Yes	66	1144	0.56 (0.39−0.79)
Fruit, nut, or berry acreage (acres)			
0	69	668	1.00 (referent level)
1−30	37	598	0.60 (0.40−0.91)
31−190	25	429	0.56 (0.35−0.91)
>190	4	117	0.33 (0.12−0.92)

[a] Mantel−Haenszel test for trend, $p < 0.01$.

Table 7. California Farmer Health Study: Logistic regression model[a] of risk factors for occupational injury.

Factor	Odds Ratio	95% CI
Age (years)[b]		
≥65	1.00	Referent level
45−64	1.38	0.84−2.26
19−44	1.99	1.18−3.37
Ethnicity		
Nonwhite	1.00	Referent level
White	3.19	1.38−7.36
Reported hours worked on farm in preceding 12 months (h)[b]		
1−480	1.00	Referent level
481−1440	2.35	1.24−4.46
1441−3500	2.35	1.26−4.38
>3500	3.00	1.26−7.12
Percent of time working with livestock in preceding 12 months (%)[b]		
0	1.00	Referent level
1−50	1.50	0.97−2.32
51−100	2.01	1.24−3.24

Factor	Odds Ratio	95% CI
Percent of time spent in administrative farm work (%)		
<10	1.00	Referent level
10−50	0.73	0.48−1.11
>50	0.50	0.22−1.11

[a] Main effects model including all factors shown in table; Hosmer−Lemeshow goodness−of−fit test P = 0.93.

[b] Mantel−Haenszel test for trend, $p < 0.05$.

Discussion

We report here the findings of a population−based telephone survey of occupational injury among California farm operators. Overall risk for farm−work−related injury, expressed as one−year cumulative incidence, was 6.9%, or a mean of 8.2 injuries per 100 farmers in the preceding year. Multiple injury events (i.e., more than one event in the same individual) occurred more often than predicted by chance, suggesting that injured individuals have personal or environmental characteristics that raise injury risk. This observation supports the argument, commonly made by injury researchers, that accidents do not happen inevitably and by random chance, but are associated with personal and environmental risk factors that may be modified to reduce risk. Overexertion was the most common external cause, leading to strains and sprains, usually involving the back. Approximately two−thirds of injuries caused the patient to seek medical care, one−third was associated with lost work time only, and a small minority required hospitalization. Injury risk was independently associated with younger age, white ethnicity, increased time working on the farm, low levels of administrative work, and increased time working with livestock.

Injury incidence and characteristics in this study were similar to those seen in regional and national studies in North America (Browning et al., 1998; Gerberich et al., 1993; Hoskin et al., 1988; Lewis et al., 1998; Merchant et al., 2002; Myers, 1998; Pickett et al., 1995a; Pratt et al., 1992; Sprince et al., 2003b). In general, these studies show the most common conditions to be strains and sprains and open wounds or lacerations, with overexertion, machinery, falls, and animals as important external causes.

Our finding of an increased risk of FWR injury among white operators has been reported in recent studies. An approximate doubling of risk for nonfatal farm injuries was noted among white owner−operators compared to African−American owner operators in the rural south (Lyman et al., 1999). McGwin et al. (2000) observed lower injury rates but higher severity among rural African−American farmers compared to white farmers in the rural southern U.S., suggesting possible underreporting of less severe injuries. This effect, if present, could have contributed to our observed higher injury risk among whites. Studies from New Mexico and North Carolina have shown higher fatal injury rates among nonwhites compared to other ethnic groups (Crandall et al., 1997; Richardson et al., 1997). However, use of our data for comparison between ethnic groups requires caution because of our relatively small number of nonwhite subjects.

We noted an increased risk for younger farmers. Previous research has not shown a clear effect of age, with some studies showing increased risk for older ages (Hoskin et al., 1988; Pratt et al., 1992) and others showing increased risk for younger workers (Sprince et al., 2003a; Sprince et al., 2003b; Zhou and Roseman, 1994). It is possible that the increased risk among the younger PFOs relates to more work hours or more

hazardous tasks. Although the multivariate model includes annual hours spent in farm work, there may be residual confounding affecting our results.

We found no increased risk for owners compared to nonowners, in contrast to findings by other investigators in the rural south (Zhou and Roseman, 1994), Ontario (Brison and Pickett, 1992) and in New York (Pratt et al., 1992) showing increased risk for owners ranging from 1.5 to 3.4 fold. The underlying reason for this discrepancy is unclear. Increased risk for owners in other studies probably relates to the owner's greater need, compared to employees, to assure that tasks are completed. This may lead to greater urgency and time pressure, with attendant increased injury risk. Our respondents tended to have larger farms than U.S. farmers in general. Farmers with larger operations may have more resources, such as employees to share the work and up−to−date equipment, thus reducing the owner's risk.

Increased hours working on the farm were related to cumulative incidence of injury in dose−dependent fashion. This is consistent with expectation, because risk of injury will vary with duration of exposure to farm hazards. Other investigators have reported similar findings (Brison and Pickett, 1992; Browning et al., 1998; Nordstrom et al., 1995; Sprince et al., 2002; Sprince et al., 2003b; Zhou and Roseman, 1994). Our finding of an inverse association between percentage of time spent in administrative work and cumulative injury incidence is also consistent with low exposures to farm hazards with administrative work. We also noted increased risk associated with working with livestock, consistent with results of other studies (Brison and Pickett, 1992; Cleary et al., 1961; Cogbill et al., 1991; Nordstrom et al., 1995; Pickett et al., 1995b; Purschwitz and Field, 1990; Sprince et al., 2003b; Zhou and Roseman, 1994).

The major strengths of this study are its large size and inclusion of the broad range of California agriculture. One potential source of bias is the underrepresentation of operators with small farms in the CASS database from which our sample came. A 1992 National Agricultural Statistics Service assessment of the CASS database showed that only 23% of small farms were included (Geuder, 1992). In contrast, over 82% of large farms (sales of $100,000+) were included. Because small farms are associated with higher injury risk than are large farms (Hoskin et al., 1988), true injury risk may be higher than we observed. While the study reflects the experience of California owner−operators, it did not include other important distinct demographic and occupational groups, such as hired farm laborers and farm children. These and other groups are the subject of other reports (McCurdy and Carroll, 2000; McCurdy et al., 2003).

The healthy−worker effect may also have affected study results. Farmers at high risk for injury due to disability or previous injury are more likely to have reduced their production below the level required for listing in the CASS database. Injured farmers may also have been less accessible for sampling. Exclusion of this group would bias our results toward lower observed injury incidence. Similarly, farms at which the operator suffered a fatal injury are more likely to be unavailable for inclusion. This may have contributed to our finding only nonfatal injuries.

We did not attempt to validate self−reported data on injuries in this study. Recall bias may have affected our findings even though we limited our data to the year preceding the interview to improve recall. Pratt found that 100% of reported visits to emergency rooms were confirmed by medical records (Pratt et al., 1992). However, these visits to emergency rooms likely represent the most severe injuries. Recall bias associated with injuries not requiring hospitalization may be more likely to affect study results, leading to a bias toward lower observed injury risk and toward more severe injuries (Jenkins et al., 2002). Although underreporting would lead to an underestimation of true risk, it would not affect exposure−injury associations unless there was a differential

reporting bias related to exposure, which we think unlikely. Finally, associations observed in a cross−sectional study may not be causal. Longitudinal studies provide a stronger basis for concluding causality.

If the injury experience of this study is applied to all 74,000 California farms, we estimate there are over 6,000 injuries annually among PFOs in the state (assuming one PFO per farm operation), including approximately 150 hospitalizations, 1850 lost−work−day cases, and 375 permanent disabilities. Younger age, increased work hours, work with livestock, and low levels of administrative work were correlated with increased injury risk. Persons with these characteristics comprise higher−risk groups and should be the focus of further study and preventive programs. Although whites also constituted a high−risk group, the small number of nonwhite farmers in this study, together with the absence of consistent data in the occupational−health literature regarding the effect of race on injury morbidity, suggests that prevention programs among farmers should be broadly applied with respect to ethnicity. Prevention efforts should focus on overexertion leading to strains and sprains, especially of the back.

Injury prevention revolves around engineering controls, education, and enforcement of existing regulations. Engineering controls are likely to be helpful for machinery−related accidents, such as those involving unguarded moving parts. Rollover protection devices, for example, have been shown to reduce mortality from tractor rollovers (Thelin, 1990). Educational measures are necessary, but may not be sufficient for injury prevention. There are few data showing reduced injury risk due to educational measures (DeRoo and Rautiainen, 2000; Murphy et al., 1996). Although regulatory enforcement is effective for injury reduction, this measure can only be helpful for situations in which a specific regulatory statute exists, and practical problems associated with monitoring the nation's nearly two million farms limit the feasibility and effectiveness of regulatory approaches.

Conclusions

We found a risk for occupational injury among California principal farm operators of 6.9% (one−year cumulative incidence), or a mean 8.2 injuries per 100 farmers in the preceding year. The greater−than−expected frequency of multiple injury events supports the argument that injury−producing events do not happen inevitably and randomly, but are associated with personal or environmental risk factors that may be modified to reduce risk. Although work injuries were heterogeneous, the most common external cause was overexertion, leading to strains and sprains, most frequently involving the back. Increased risk was associated with younger age groups, white ethnicity, increased annual hours of farm work, reduced level of administrative work, and work with livestock. Injury reduction programs should include ergonomic investigation and interventions focused on higher−risk groups.

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