Agricultural Injury Among Rural California Public High School Students

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Objectives *The University of California, Davis Youth Agricultural Injury Study characterized the farm work and agricultural injury experience among rural California Central Valley public high school students enrolled in an agricultural sciences curriculum.*

Methods *We conducted a cross-sectional survey of agricultural injury among students from 10 California Central Valley high schools during the 2001–2005 school years.*

Results *Of 1,783 subjects, 946 (53.1%) reported farm work in the previous year, including 97 (10.3%) reporting at least one farm work-related injury in the preceding year. After adjustment for sex, ethnicity, and hours spent in farm work, injury risk was associated with large-animal operations (OR 4.15; 95%CI: 1.18, 14.65), feeding large animals (OR 2.38; 95%CI: 1.15, 4.96), mixing chemicals (OR 1.86; 95%CI: 1.15, 3.03), welding (OR 2.09; 95%CI: 1.17, 3.72), non-use of seatbelts, and frequent riding in the back of an uncovered pick-up truck. Risky attitudes toward farm safety were significantly associated with injury. Girls were more likely to suffer an animal-related injury and boys to suffer injury related to motor vehicles, machinery, or tool use.*

Conclusions *Adolescents are at similar risk to adults for agricultural injury. Although limitations on hazardous tasks and time spent on farm work are likely to be the most efficacious means for reducing injury, education will play an important role. Educational measures should include inculcating healthy safety-related attitudes and focus on hazardous tasks, such as those involving animals (for girls) and motor vehicles and machinery (for boys).* Am. J. Ind. Med. 55:63–75, 2012. © *2011 Wiley Periodicals, Inc.*

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INTRODUCTION

Agriculture has historically been recognized as a hazardous industry and differs from others in its frequent use of child labor and relatively lower level of legal protections for children [McCurdy and Carroll, 2000]. Under the Fair Labor Standards Act of 1938, children as young as 12 may legally work full-time in agriculture during school breaks, an exception to the required minimum age of 14 in other industries [Foster et al., 1997]. Moreover, there are no age or work restrictions for youth working on their family farm.

The public health implications of child farm work are substantial: 1.1 million children and adolescents under 20 years of age resided on farms in 2006, over half of whom work on farms, and an additional 307,000 children and adolescents not resident on farms were hired to work

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on farms [NIOSH, 2009]. There were 22,648 injuries among persons younger than 20 years of age who lived, worked, or visited a farm or ranch in 2001, representing a cumulative 1-year injury incidence of 12.7/1,000 among household and hired youth [US Department of Agriculture, 2004]. Approximately one-third of these injuries were work-related, and the majority occurred among males. In the period 1995–2002, 907 youth died on farms ($8.4/10^5$ youth/year), and 13% of these were work-related [NIOSH, 2009]. Up to 40% of nonfatally injured children are left with a permanent disability [Cogbill et al., 1985; Swanson et al., 1987; Zietlow and Swanson, 1999].

Efforts to reduce the toll of agricultural injury have revolved around engineering improvements, regulatory enforcement, and education [Aherin et al., 1990]. Engineering improvements, for example, protective guards around moving machinery parts, tend to be highly effective if they reduce or eliminate exposure to hazards. Regulatory enforcement depends on the acceptability of a regulatory regime by the farmer and the human and financial resources available for enforcement. Engineering and regulatory approaches can be expensive.

Education is an attractive option because of its relative low cost and acceptability to farm employers compared to engineering changes and regulatory enforcement. Most safety education programs have not demonstrated improvements in safety behavior or injury risk [Rautiainen et al., 2008], although some have provided hopeful results [Reed et al., 2003; Teran et al., 2008]. For example, over three-quarters of students participating in the Agricultural Disability Awareness and Risk Education Project (AgDARE) subsequently made positive safety changes to their agricultural practices [Reed et al., 2003].

The University of California, Davis Youth Agricultural Injury Study (UCD-YAIS) examined agricultural injury risk among rural California Central Valley public high school students participating in agricultural sciences programs at their schools. The aims of the study were to characterize the population with respect to demographic and work characteristics with respect to injury risk and to identify specific risk factors for injury. We report here results of the initial cross-sectional component of the study.

MATERIALS AND METHODS

Study Design Overview

The UCD-YAIS is a cross-sectional survey with annual follow-up among California Central Valley public high school students enrolled in the state-approved agriculture curriculum. Ten high schools were selected from a list provided by the California Department of Education based on their location in agricultural communities and participation in the state's agriculture education curriculum.

We initially contacted the schools' principals and agricultural sciences instructors to describe and promote the study. All 10 schools contacted agreed to participate. Study personnel visited each school to obtain input from students and teachers regarding the focus of the study, perceptions on farm work and hazards, and for questionnaire development. During the data collection phase, study personnel visited each school to describe and promote the study among students. English and Spanish parental consent and student assent forms were distributed following the presentations. Study personnel then revisited each school, typically within a week of the initial presentation, to administer the questionnaires to those with parental consent to participate. Subjects received as participation incentive gift certificates worth $5 redeemable through local food vendors, as recommended by student focus groups. The University of California, Davis Office Institutional Review Board (UCD IRB) approved the study and related materials. Data collection began in late January 2002 and ended in May 2005.

Survey Questionnaire

Where possible, we used previously validated questions from standardized questionnaires (e.g., National Health Interview Survey, National Health and Nutrition Examination Survey). The questionnaire addressed demographic characteristics, health status and habits, sources of agricultural health and safety information, attitudes toward agricultural work, safety habits, smoking and respiratory history, work history and agricultural injury history. Subjects reporting a qualifying agricultural injury completed a detailed injury-experience module. Questions were in multiple choice-, numeric entry-, and text-entry formats. Subjects were identified on the questionnaire only by an assigned subject identification number. Study personnel administered the questionnaire during class time with the consent of the instructor; the questionnaire required approximately 45 min to complete.

Data Management and Analysis

We used a scannable questionnaire with the Teleform (Cardiff, Vista, CA) data processing program and the Stata (StataCorp LP, College Station, TX) statistical software package for data management and analysis.

Variables relating to acreage or hours worked were categorized using approximate tertile or quartile groupings. Farm crops or commodities were assigned to grain, row, tree, small animal, large animal, or ''other''

categories. Smoking status (current/former/never) was determined by historic and current smoking experience. A qualifying agricultural injury event was defined as an event in the preceding year necessitating at least one of the following: (a) professional medical attention, (b) loss of at least one-half day of school or work, or (c) reduction of work or usual activity for at least one-half day. We excluded cases for which no narrative descriptive information was provided. Where multiple injuries occurred, we considered the most recent. Nature and external cause of injury were categorized by nosologists at the University of California Davis Medical Center based on the ICD-9 classification system [World Health Organization, 1977]. Body parts affected by injury were categorized using the Occupational Injury and Illness Classification Manual [US Department of Labor, 2007]. A composite safety attitude index comprised the numerical values associated with Likert-scale responses (ranging from strongly disagree to strongly agree) to safety-related questions (Table V). High values for the composite safety attitude index indicated risky attitudes.

We summarized continuous variables with mean and standard deviation (for normal distributions) and median and percentile score (for nonnormal distributions). We summarized categorical variables as percentages within each category. We conducted initial two-way tabular analysis to identify variables associated with injury, followed by stratification to evaluate for potential confounding. We then utilized multivariable logistic regression analysis to assess the independent associations with injury for important variables while adjusting for sex, ethnicity (White/Hispanic/Other), and hours per year of farm labor (0–300/301–600/601–1,500/1,501+).

RESULTS

Study Sample and Demographic Characteristics

There were 1,783 participants. During the first two annual cycles of data collection we employed an active consent process, allowing participation only for students providing a consent form signed by a parent or guardian. This process yielded 669 subjects and an average participation rate of 39.5% of students present on the survey day. The UCD IRB subsequently approved a passive consent process, in which students were allowed to participate unless the parent or guardian provided a written statement prohibiting participation. The passive process was used for the remaining 2 years of data collection and yielded 1,114 subjects and a participation rate of approximately 100% of students present on the survey day. The passive informed consent regime group contained a higher percentage of boys (75.0% vs. 67.4%, $P < 0.01$), a lower likelihood of working on a farm or ranch in the preceding year (48.8% vs. 60.1%, $P < 0.001$), and a lower 1-year cumulative incidence of injury (3.8% vs. 8.2%, $P < 0.01$) compared to the active informed-consent group. The two groups appeared otherwise comparable and were therefore combined. Exploratory inclusion of the consent process in subsequent modeling did not significantly alter odds ratios for other variables and was not included in final analyses.

Subjects were predominantly male and in their middle teenage years (Table I). Over half of the sample was White, and approximately 90% were born in the US. Approximately one-quarter of the students came from homes in which at least one parent had a 4-year college degree.

Farm and Farm Work Characteristics

Nine hundred forty-six (53.1%) subjects reported working on a ranch or farm in the previous year. Of these, more than half also lived on a farm (Table II). The median farm size among those working and living on a farm was 32 acres (13 hectares); the most common main agricultural products were large animals (chiefly cattle) and tree crops. Most subjects working in a farm or ranch worked on their family holding (Table III). Subjects working on a farm or ranch in the preceding year reported a median of 650 farm work hours per year.

Persons working on a farm in the past year, in comparison to their peers who did not perform farm work, were more likely to be male (76.2% vs. 67.6%, $P < 0.001$), be older (median age 16 vs. 15 years, $P < 0.05$), have White ethnicity (66.1% vs. 44.9%, $P < 0.001$), take more agriculture-related courses in school ($P < 0.001$), be members of the National Future Farmers of America (FFA) youth agricultural organization (83.3% vs. 68.2%, $P < 0.001$), ride motorcycles (61.4% vs. 37.0%, $P < 0.001$) and all-terrain vehicles (69.5% vs. 32.6%, $P < 0.001$), and ride in the back of uncovered pickup trucks on more than 15 occasions in the past year (21.9% vs. 6.2%, $P < 0.001$).

Subjects performed a full range of farm tasks (Table III). The least frequent activities were mixing and applying chemicals, and the most common was feeding small animals. Approximately two-thirds of subjects reported operating a tractor. Among those performing selected farm tasks, the median age for beginning the tasks ranged from 8 (feeding small animals) to 14 years (welding). Median age for beginning a task was 13 for mixing or applying chemicals, 12 for operating tractors or other machinery, and 10 years for feeding large animals and for manual harvest work.

Boys were more likely than girls to operate a tractor (71.8% vs. 50.7%, $P < 0.001$), operate other heavy

TABLE I. Selected Demographic Characteristics and Injury Risk Among 1,783 Rural California High School Students

Characteristic	Frequency [n (%)] Entire sample (n = 1,783)	Frequency [n (%)] Farm work in past year (n = 946)	Cumulative 1-year injury incidence[a] [n (%)]	Adjusted odds ratio for injury[ab] (95%CI)
Sex				
Male	1,287 (72.2)	721 (76.2)	71 (9.9)	1.00 Referent
Female	496 (27.8)	225 (23.8)	26 (11.6)	1.12 (0.66, 1.88)
Age [mean ± SD years]				
Male	15.7 ± 1.28	15.8 ± 1.26	—	—
Female	15.3 ± 1.21	15.2 ± 1.19		
Grade				
9th	567 (31.8)	279 (29.5)	27 (9.7)	1.00 Referent
10th	488 (27.4)	263 (27.8)	27 (10.3)	0.76 (0.42, 1.39)
11th	342 (19.2)	194 (20.5)	20 (10.3)	0.81 (0.42, 1.54)
12th	373 (20.9)	207 (21.9)	23 (11.1)	0.94 (0.50, 1.75)
Not stated	13 (0.7)	3 (0.3)	0 (0)	—
Ethnicity[c]				
White	997 (55.9)	625 (66.0)	75 (12.0)	1.00 Referent
Hispanic	600 (33.7)	212 (22.4)	5 (2.4)	0.16 (0.06, 0.46)
Other	162 (9.1)	98 (10.4)	17 (17.4)	1.62 (0.89, 2.94)
Not stated	24 (1.4)	11 (1.2)	0 (0)	—
Place of birth				
USA	1,590 (89.2)	865 (91.4)	93 (10.8)	1.00 Referent
Mexico	161 (9.0)	67 (7.1)	3 (4.5)	1.73 (0.28, 10.66)
Other	18 (1.0)	9 (1.0)	1 (11.1)	0.77 (0.69, 6.47)
Not stated	14 (0.8)	5 (0.5)	0 (0)	—
High school				
A	102 (5.7)	54 (5.7)	5 (9.3)	1.00 Referent
B	102 (5.7)	69 (7.3)	14 (20.3)	2.33 (0.75, 7.23)
C	77 (4.3)	53 (5.6)	6 (11.3)	1.18 (0.32, 4.32)
D	254 (14.3)	121 (12.8)	7 (5.8)	0.77 (0.22, 2.62)
E	137 (7.7)	93 (9.8)	12 (12.9)	1.23 (0.39, 3.85)
F	214 (12.0)	103 (10.9)	6 (5.8)	1.42 (0.39, 5.23)
G	247 (13.9)	145 (15.3)	21 (14.5)	1.66 (0.57, 4.86)
H	255 (14.3)	165 (17.4)	17 (10.3)	1.25 (0.42, 3.72)
I	246 (13.8)	90 (9.5)	7 (7.8)	0.94 (0.26, 3.39)
J	149 (8.4)	53 (5.6)	2 (3.8)	1.03 (0.17, 6.24)
Parents with 4-year college degree				
Neither	961 (53.9)	474 (50.1)	43 (9.1)	1.00 Referent
One	326 (18.3)	206 (21.8)	25 (12.1)	1.09 (0.62, 1.91)
Both	161 (9.0)	107 (11.3)	13 (12.2)	1.06 (0.53, 2.10)
Not sure	321 (18.0)	152 (16.1)	16 (10.5)	1.33 (0.70, 2.52)
Not stated	14 (0.8)	7 (0.7)	0 (0.0)	—

[a]Analysis limited to 946 subjects who reported working on a farm or ranch in the preceding year.
[b]Adjusted for sex, ethnicity (White/Hispanic/Other), and hours per year of farm labor (0–300/301–600/601–1,500/1,501+).
[c]$P < 0.01$, likelihood ratio test based on a comparison of the multivariable regression model including the variable with a reduced model not including the variable.

machinery (57.7% vs. 25.8%, $P < 0.001$), mix chemicals (32.3% vs. 16.0%, $P < 0.001$), apply chemicals (38.7% vs. 28.0%, $P < 0.05$), and weld (64.2% vs. 26.2%, $P < 0.001$). Girls were more likely than boys to feed large animals (82.7% vs. 68.2%, $P < 0.001$) and small animals (89.8% vs. 74.6%, $P < 0.001$). For all tasks, the median age at initiation differed by 1 year or less between boys and girls. Hispanic respondents were less likely than Whites to report operating tractors (61.1% vs. 73.6%, $P < 0.001$) or heavy machinery (47.7% vs. 55.1%, NS),

TABLE II. Selected Farm or Ranch Characteristics and Injury Risk Among 946 Rural California High School Students Who Worked on a Farm or Ranch in the Preceding Year

Characteristic	Frequency [n (%)]	Cumulative 1-year injury incidence [n (%)]	Adjusted odds ratio for injury[a] (95%CI)
Live on a farm or ranch			
No	432 (45.7)	27 (6.3)	1.00 Referent
Yes	509 (53.8)	70 (13.8)	1.55 (0.94, 2.57)
Not stated	5 (0.5)	0 (0.0)	—
Years lived on farm or ranch[b]			
Mean ± SD	11.3 ± 5.2		
Median	14.0		
Size of farm or ranch[b] [acres]			
1–15	162 (31.8)	23 (14.2)	1.00 Referent
16–45	106 (20.8)	14 (13.2)	0.95 (0.45, 2.00)
46–145	86 (16.9)	17 (19.8)	1.42 (0.67, 2.98)
146+	113 (22.2)	13 (11.5)	0.60 (0.28, 1.31)
Not stated	42 (8.3)	3 (7.1)	—
Main crop or commodity[bc]			
Grain crops	48 (9.4)	3 (6.3)	1.00 Referent
Row crops	114 (22.4)	10 (8.8)	1.77 (0.45, 6.95)
Tree	119 (23.4)	19 (16.0)	3.45 (0.94, 12.62)
Small animal	11 (2.2)	1 (9.1)	3.84 (0.31, 47.73)
Large animal	147 (28.9)	31 (21.1)	4.15 (1.18, 14.65)
Other	28 (5.5)	3 (10.7)	1.13 (0.17, 7.48)
Not stated	42 (8.3)	3 (7.1)	—

[a]Adjusted for sex, ethnicity (White/Hispanic/Other), and hours per year of farm labor (0–300/301–600/601–1,500/1,501+).
[b]Analysis limited to 509 subjects who reported living and working on a farm or ranch in the preceding year.
[c]$P < 0.05$, likelihood ratio test based on a comparison of the multivariable regression model including the variable with a reduced model not including the variable.

TABLE III. Selected Farm Work Characteristics and Injury Risk Among 946 Rural California High School Students Who Worked on a Farm or Ranch in the Preceding Year

Characteristic	Frequency [n (%)]	Cumulative 1-year injury incidence [n (%)]	Adjusted odds ratio for injury[a] (95%CI)
Ownership of farm or ranch worked			
Family	569 (60.2)	67 (11.8)	1.00 Referent
Non-family	258 (27.3)	24 (9.3)	1.33 (0.78, 2.26)
Farm labor contractor	47 (5.0)	1 (2.1)	0.40 (0.05, 3.19)
Other	57 (6.0)	5 (8.8)	0.87 (0.29, 2.60)
Not stated	15 (1.6)	0 (0)	—
Hours worked per year[b]			
0–300	200 (21.1)	8 (4.0)	1.00 Referent
301–600	190 (20.1)	20 (10.5)	2.98 (1.27, 6.99)
601–1,500	247 (26.1)	25 (10.1)	2.74 (1.19, 6.27)
1,501+	202 (21.4)	41 (20.3)	6.02 (2.70, 13.45)
Not stated	107 (11.3)	3 (2.8)	—
Tasks performed[c]			
Operate a tractor	632 (66.8)	80 (12.7)	1.90 (0.96, 3.77)
Operate other heavy machinery	474 (50.1)	62 (13.1)	1.31 (0.78, 2.22)
Mix chemicals	269 (28.4)	44 (16.4)	1.86 (1.15, 3.03)
Apply chemicals	342 (36.2)	48 (14.0)	1.40 (0.87, 2.26)
Feed large animals	678 (71.7)	87 (12.8)	2.38 (1.15, 4.96)
Feed small animals	740 (78.2)	87 (11.8)	1.57 (0.72, 3.45)
Harvest by hand	278 (29.4)	38 (13.7)	1.58 (0.98, 2.54)
Welding	522 (55.2)	71 (13.6)	2.09 (1.17, 3.72)
Number of selected tasks (above) performed[b]			
0–2	173 (18.3)	5 (2.9)	1.00 Referent
3–4	264 (27.9)	21 (8.0)	2.23 (0.80, 6.19)
5–6	256 (27.1)	35 (13.7)	3.34 (1.21, 9.20)
7–8	157 (16.6)	28 (17.8)	4.30 (1.48, 12.47)
Not stated	96 (10.2)	8 (8.3)	—

[a]Adjusted for sex, ethnicity (White/Hispanic/Other), and hours per year of farm labor (0–300/301–600/601–1,500/1,501+).
[b]$P < 0.005$, test for trend.
[c]Reference group for odds ratio is persons not performing the stated task.

mixing chemicals (16.9% vs. 35.4%, $P < 0.001$), applying chemicals (24.7% vs. 44.6%, $P < 0.001$), feeding large animals (68.5% vs. 76.7%, $P < 0.05$) or small animals (74.6% vs. 84.0%, $P < 0.01$), and welding (54.4% vs. 59.9%, NS). Median ages for Hispanic respondents engaging in these activities were 1–3 years older at initiation than for their White counterparts.

Safety-Related Information, Attitudes, and Habits

Over three-quarters of subjects were FFA members (Table IV). Subjects most frequently acknowledged their father as the ''most important'' source of agricultural safety information, followed by their mother and high school teachers. We asked three questions intended to illustrate attitudes toward safety (Table V). Over 90% of subjects agreed or strongly agreed that safety is necessary even if it slows the job, and approximately one-fifth disagreed or strongly disagreed that injuries cannot be prevented. Over half of subjects working on a farm or ranch in the preceding year believed they were less likely to be injured than their peers. Fewer than 10% were current smokers; approximately 10% of subjects working on a farm or ranch in the past year used chewing tobacco (Table VI). Approximately half of subjects reported always using seatbelts. Approximately one-third of subjects always used helmets when riding motorcycles, and approximately one-quarter always used helmets when riding an all-terrain vehicle.

TABLE IV. Sources of Agricultural Safety Information and Injury Risk Among 1,783 Rural California High School Students

Characteristic	Frequency [n (%)] Entire sample (n = 1,783)	Farm work in past year (n = 946)	Cumulative 1-year injury incidence[a] [n (%)]	Adjusted odds ratio for injury[ab] (95%CI)
Number of agricultural courses taken from 7th to 12th grade				
0–1	839 (47.1)	370 (39.1)	27 (7.3)	1.00 Referent
2–4	830 (46.6)	490 (51.8)	55 (11.2)	1.22 (0.73, 2.04)
5+	114 (6.4)	86 (9.1)	15 (17.4)	1.70 (0.82, 3.53)
Member, FFA[c]				
No	387 (22.2)	141 (14.9)	10 (7.1)	1.00 Referent
Yes	1,360 (76.3)	788 (83.3)	85 (10.8)	1.21 (0.59, 2.46)
Not stated	36 (2.0)	17 (1.8)	2 (11.8)	—
Member, 4-H[c]				
No	1,628 (91.3)	821 (86.8)	76 (9.3)	1.00 Referent
Yes	120 (6.7)	106 (11.2)	19 (17.9)	1.62 (0.90, 2.92)
Not stated	35 (2.0)	19 (2.0)	2 (10.5)	—
Acknowledged as "very important" source of agricultural safety information vs. "not important at all"				
Father	1,024 (57.4)	572 (60.5)	56 (9.8)	0.52 (0.24, 1.13)
Mother	852 (47.8)	438 (46.3)	40 (9.1)	0.74 (0.33, 1.67)
Other relative	558 (31.3)	295 (31.2)	25 (8.5)	0.76 (0.34, 1.73)
High school teachers	711 (39.3)	369 (39.0)	41 (11.1)	1.23 (0.48, 3.16)
FFA[c]	618 (34.7)	334 (35.3)	40 (12.0)	1.03 (0.47, 2.25)
4-H[c]	237 (13.3)	134 (14.2)	21 (15.7)	1.23 (0.65, 2.33)
Other source	151 (8.5)	97 (10.3)	17 (17.5)	4.58 (1.23, 17.08)

[a]Analysis limited to 946 subjects who reported working on a farm or ranch in the preceding year.
[b]Adjusted for sex, ethnicity (White/Hispanic/Other), and hours per year of farm labor (0–300/301–600/601–1,500/1,501+).
[c]FFA (National Future Farmers of America) and 4-H (Head, Heart, Hands, Health) are national agricultural youth organizations.

Injury Experience

There were 97 (5.4%) qualifying agricultural injuries in the preceding year among the 1,783 subjects; 71 (73.2%) of these occurred in boys and 26 (26.8%) in girls. Injuries occurred uniquely among the 946 persons working on a ranch or farm in the preceding year. We calculated a 1-year cumulative incidence of 10.3% based on this smaller denominator because persons not engaged in farm work were at negligible risk for agricultural injury. There was a median of two injuries in the preceding year among subjects reporting at least one injury.

Injury risk was related in step-wise fashion to annual hours spent in farm work (Table III). After adjustment for farm work hours, ethnicity, and sex, we observed increased overall injury risk (i.e., not limited to injuries occurring in performance of the specified tasks) associated with each of eight selected farm tasks. Mixing chemicals, feeding large animals, and welding each showed a statistically significant approximate doubling of odds for injury. The number of these selected tasks performed showed a significant trend with injury risk.

There was a modest and non-statistically significant step-wise increase in risk according to the number of agricultural science courses taken (Table IV). Risky attitudes, reflected as high values for the composite safety attitude index, also showed a significant trend with injury, with the highest category manifesting more than two-fold increased odds of injury (Table V). Among safety-related habits, riding in the back of an uncovered pickup truck in the past 12 months and seat belt use were significantly associated with injury risk in step-wise fashion (Table VI).

Description of Injuries

Contusions represented the most common injury overall and predominated in girls, in whom they comprised over one-third of cases (Table VII). Girls were nearly twice as likely as boys to suffer fractures. Of the six fractures among girls, all but one were animal-related. The foot and ankle were most commonly injured among girls (nearly one-quarter of cases), and the upper extremity, including wrist and hand, were most common among boys (approximately one-third of cases; Table VIII). Among

TABLE V. Attitudes Towards Farm Work and Safety and Injury Risk Among 1,783 Rural California High School Students

Attitude statement, response, and (ordinal risk index value)	Frequency [n (%)]		Cumulative 1-year injury incidence[a] [n (%)]	Adjusted odds ratio for injury[ab] (95%CI)
	Entire sample (n = 1,783)	Farm work in past year (n = 946)		
"No matter how hard you try to prevent them, serious injuries are going to occur on a farm or ranch"[c]				
Strongly agree (3)	398 (22.3)	243 (25.7)	36 (14.8)	2.30 (0.63, 8.43)
Agree (2)	1,013 (56.8)	506 (53.5)	44 (8.7)	1.43 (0.39, 5.20)
Disagree (1)	305 (17.1)	159 (16.8)	13 (8.2)	1.11 (0.28, 4.41)
Strongly disagree (0)	56 (3.1)	34 (3.6)	3 (8.8)	1.00 Referent
Not stated	11 (0.6)	4 (0.4)	1 (25.0)	—
"Safety precautions are important and necessary, even if they slow the job"[c]				
Strongly agree (0)	785 (44.0)	384 (40.6)	27 (7.0)	1.00 Referent
Agree (1)	862 (48.4)	491 (51.9)	58 (11.8)	1.75 (1.06, 2.90)
Disagree (2)	95 (5.3)	54 (5.7)	9 (16.7)	2.39 (1.01, 5.66)
Strongly disagree (3)	29 (1.6)	12 (1.3)	2 (16.7)	2.32 (0.42, 12.64)
Not stated	12 (0.7)	5 (0.5)	1 (20.0)	—
"I am less likely to be injured doing farm work than other people my age doing the same work."				
Strongly agree (3)	249 (14.0)	162 (17.1)	24 (14.8)	1.07 (0.42, 2.74)
Agree (2)	606 (34.0)	360 (38.1)	35 (9.7)	0.88 (0.36, 2.19)
Disagree (1)	762 (42.7)	346 (36.6)	30 (8.7)	0.75 (0.30, 1.88)
Strongly disagree (0)	152 (8.5)	73 (7.7)	7 (9.6)	1.00 Referent
Not stated	14 (0.8)	5 (0.5)	1 (20.0)	—
Composite safety attitude risk index[cd]				
0–3	521 (29.2)	223 (23.6)	14 (6.3)	1.00 Referent
4–5	995 (55.8)	554 (58.6)	57 (10.3)	1.64 (0.86, 3.13)
6–9	251 (14.1)	163 (17.2)	25 (15.3)	2.29 (1.10, 4.79)
Not stated	16 (0.9)	6 (0.6)	1 (16.7)	—

[a]Analysis limited to 946 subjects who reported working on a farm or ranch in the preceding year.
[b]Adjusted for sex, ethnicity (White/Hispanic/Other), and hours per year of farm labor (0–300/301–600/601–1,500/1,501+).
[c]$P < 0.05$, test for trend.
[d]Composite safety attitude risk index is the sum of the ordinal values of response for each of the three safety attitude questions cited above; increasing values indicate increasingly risky attitudes toward safety.

girls, animals or rides on animals were the external cause for nearly three-quarters of cases (Table IX). Boys experienced injury from a wider range of external causes; the most predominant were machine or hand tools and animals, closely followed by motor vehicles and falls. There were 10 incidents involving tractors, nine of which involved boys.

The most common time frame for injury was 2:00 p.m. to 6:00 p.m. (n = 30, 30.9% of injuries). Injured subjects had been working a median of 4 hr at the time of injury. Nine (9.3%) injuries eventuated in chronic sequelae, typically involving difficulty with lifting heavy objects or pain. The most frequently cited contributing factor was personal carelessness (n = 34, 35.1% of injuries), followed by loss of balance (n = 29, 29.9%) and distraction (n = 22, 22.7%).

The most common qualifying criterion for injury was the need for at least ½ day of light duty at work (n = 60, 61.9% of injuries, median 4 days), followed by loss of at least ½ day of school or work (n = 54, 55.7% of injuries, median 2 days) and need for medical care (n = 46, 47.4% of injuries). Only one subject required hospitalization for more than 24 hr. The likelihoods for each of these qualifying criteria and the number of days involved (missed school or work, light duty, hospitalization) were similar across sex, grade, ethnicity, years farming, acreage, crops, farm ownership, whether or not safety instruction had been received prior to injury, and passive versus active informed consent.

DISCUSSION

We report here the cross-sectional findings of the UCD-YAIS, addressing the agricultural injury experience among youth participating in an agricultural sciences program in rural California Central Valley public high

TABLE VI. Selected Safety Habits and Injury Risk Among 1,783 Rural California High School Students

Characteristic	Frequency[a] [n (%)] Entire sample (n = 1,783)	Frequency[a] [n (%)] Farm work in past year (n = 946)	Cumulative 1-year injury incidence[b] [n (%)]	Adjusted odds ratio for injury[bc] (95%CI)
Smoking status				
Never smoker	1,468 (82.3)	773 (81.7)	72 (9.3)	1.00 Referent
Former smoker	66 (3.7)	43 (4.6)	5 (11.6)	1.28 (0.47, 3.51)
Current smoker	116 (6.5)	64 (6.8)	11 (17.2)	1.44 (0.70, 3.00)
Not stated	133 (7.5)	66 (7.0)	9 (13.6)	—
Use chewing tobacco				
No	1,611 (90.4)	821 (86.8)	78 (9.5)	1.00 Referent
Yes	119 (6.7)	99 (10.5)	17 (17.2)	1.60 (0.87, 2.93)
Not stated	53 (3.0)	26 (2.8)	2 (7.7)	—
Ridden in back of uncovered pickup truck in past 12 months[d]				
Never	624 (35.0)	207 (21.9)	10 (4.8)	1.00 Referent
1–5 times	711 (39.9)	399 (42.2)	32 (8.0)	1.66 (0.76, 3.64)
6–15 times	167 (9.4)	122 (12.9)	16 (13.1)	2.45 (1.01, 5.96)
16+ times	260 (14.6)	207 (21.9)	38 (18.4)	2.87 (1.30, 6.36)
Not stated	21 (1.2)	11 (1.2)	1 (9.1)	—
Seatbelt use[d]				
Always	904 (50.7)	437 (46.2)	37 (8.5)	1.00 Referent
Nearly always	445 (25.0)	252 (26.6)	22 (8.7)	0.92 (0.51, 1.65)
Sometimes	270 (15.1)	163 (17.2)	18 (11.0)	1.28 (0.69, 2.40)
Seldom	82 (4.6)	50 (5.3)	10 (20.0)	1.74 (0.77, 3.94)
Never	62 (3.5)	34 (3.6)	9 (26.5)	2.79 (1.11, 6.98)
Not stated	20 (1.1)	10 (1.1)	1 (10.0)	—
Ridden motorcycle or moped in past year				
No	772 (43.3)	307 (32.5)	18 (5.9)	1.00 Referent
Yes	891 (50.0)	581 (61.4)	74 (12.7)	1.69 (0.95, 3.03)
Not stated	120 (6.7)	58 (6.1)	5 (8.6)	—

Characteristic	Frequency[a] [n (%)] Entire sample (n = 891)	Frequency[a] [n (%)] Farm work in past year (n = 581)	Cumulative 1-year injury incidence[b] [n (%)]	Adjusted odds ratio for injury[bc] (95%CI)
Helmet use when riding motorcycle or moped				
Always	325 (36.5)	202 (34.8)	31 (15.4)	1.00 Referent
Nearly always	165 (18.5)	106 (18.2)	16 (15.1)	0.85 (0.42, 1.71)
Sometimes	172 (19.3)	118 (20.3)	7 (5.9)	0.36 (0.15, 0.87)
Seldom	77 (8.6)	46 (7.9)	4 (8.7)	0.50 (0.16, 1.55)
Never	142 (15.9)	103 (17.7)	16 (15.5)	0.92 (0.45, 1.86)
Not stated	10 (1.1)	6 (1.0)	0 (0)	—
Ridden all-terrain vehicle (ATV) in past year				
No	707 (39.7)	223 (23.6)	10 (4.5)	1.00 Referent
Yes	932 (52.3)	657 (69.5)	85 (12.9)	1.92 (0.91, 4.05)
Not stated	144 (8.1)	66 (7.0)	2 (3.0)	—

(*Continued*)

TABLE VI. (Continued)

Characteristic	Frequency[a] [n (%)] Entire sample (n = 932)	Farm work in past year (n = 657)	Cumulative 1-year injury incidence[b] [n (%)]	Adjusted odds ratio for injury[bc] (95%CI)
Helmet use when riding ATV				
Always	255 (27.4)	159 (24.2)	16 (10.1)	1.00 Referent
Nearly always	145 (15.6)	106 (16.1)	12 (11.3)	0.89 (0.38, 2.08)
Sometimes	182 (19.5)	128 (19.5)	18 (14.1)	1.32 (0.62, 2.82)
Seldom	99 (10.6)	76 (11.6)	8 (10.5)	0.83 (0.32, 2.13)
Never	244 (26.2)	183 (27.9)	31 (16.9)	1.43 (0.72, 2.85)
Not stated	7 (0.8)	5 (0.8)	0 (0)	—

[a]Based on 1,783 or 946 subjects according to the column headings, except as indicated for helmet use when riding a motorcycle and helmet use when riding an ATV.
[b]Based on 946 subjects who reported working on a farm or ranch in the preceding year, except for helmet use when riding a motorcycle (based on 581 subjects who reported riding a motorcycle in the past year) and helmet use when riding an ATV (based on 657 subjects who reported riding an ATV in the past year).
[c]Adjusted for sex, ethnicity (White/Hispanic/Other), and hours per year of farm labor (0–300/301–600/601–1,500/1,501+).
[d]$P < 0.05$, test for trend.

schools. For the 946 participants who worked on a farm or ranch in the preceding year, injury risk was positively associated with the number of hours spent in farm work per year and was lower among Hispanic students. After adjustment for these two factors and sex (itself not statistically significant), we identified significant associations with large-animal operations and selected farm tasks, most notably feeding large animals, mixing chemicals, and welding, each of which carried an approximate doubling of odds for injury. Riding in the back of an

TABLE VII. Nature (Primary Diagnosis) of Injury Among 97 Rural California High School Students Reporting an Agricultural Injury* in the Preceding Year

ICD9 code[a]	Primary diagnosis	Frequency [n (%)] Boys	Girls	Total
370.24	Welder's keratitis	3 (4.2)	0 (0)	3 (3.1)
722.2	Displacement of intervertebral disc	1 (1.4)	0 (0)	1 (1.0)
729.81	Swelling of limb (hand)	1 (1.4)	0 (0)	1 (1.0)
780.09	Unconsciousness	1 (1.4)	1 (3.8)	2 (2.1)
800–829	Fracture	9 (12.7)	6 (23.1)	15 (15.5)
840–848, 884.9	Sprain	10 (14.1)	3 (11.5)	13 (13.4)
850	Concussion	3 (4.2)	1 (3.2)	4 (4.1)
876, 880–887	Open wound, upper limb	7 (9.9)	0 (0)	7 (7.2)
886	Traumatic amputation of finger	1 (1.4)	0 (0)	1 (1.0)
890–897	Open wound, lower limb	6 (8.5)	1 (3.8)	7 (7.2)
915.0	Friction burn, finger	1 (1.4)	0 (0)	1 (1.0)
916.0	Abrasion of hip, thigh, leg and ankle	1 (1.4)	0 (0)	1 (1.0)
922.1–924.8, 992.31	Contusion	14 (19.7)	10 (38.5)	24 (24.7)
930.9	Foreign body, eye	2 (2.8)	0 (0)	2 (2.1)
943–946	Burn	6 (8.5)	0 (0)	6 (6.2)
959.01	Unspecified head injury	0 (0)	1 (3.8)	1 (1.0)
959.19	Injury of other sites of trunk	0 (0)	3 (11.5)	3 (3.1)
989.5	Toxic effect of substance	1 (1.4)	0 (0)	1 (1.0)
	Other	4 (5.6)	0 (0)	4 (4.1)
	Total	71 (100)	26 (100)	97 (100)

*Injury occurred while working in agriculture and caused the subject to seek medical attention or lose at least one-half day of work or school time or have at least one-half day of restricted activity.
[a]Ninth Revision, International Classification of Diseases [World Health Organization, 1977].

TABLE VIII. Injured Body Part Among 97 Rural California High School Students Reporting an Agricultural Injury* in the Preceding Year

		Frequency [n (%)]		
Body part classification code[a]	**Body part injured**	**Boys**	**Girls**	**Total**
010–039 (exclude 032)	Head (except eye)	4 (5.6)	3 (11.5)	7 (7.2)
032	Eye	5 (7.0)	0 (0)	5 (5.2)
210–256 (exclude 230)	Trunk (except back and spine)	4 (5.6)	5 (19.2)	9 (9.3)
230	Back and spine	8 (11.3)	5 (19.2)	13 (13.4)
310, 340, 380	Upper extremity and shoulder (except hand and wrist)	12 (16.9)	1 (3.8)	13 (13.4)
320, 330	Wrist and hand	10 (14.1)	1 (3.8)	11 (11.3)
410, 411	Hip and thigh	4 (5.6)	0 (0)	4 (4.1)
412, 413	Knee and lower leg	7 (9.9)	3 (11.5)	10 (10.3)
420, 430, 440	Foot and ankle	8 (11.3)	6 (23.1)	14 (14.4)
800	Multiple body regions	4 (5.6)	2 (7.7)	6 (6.2)
	Other	5 (7.0)	0 (0)	5 (5.2)
	Total	71 (100)	26 (100)	97 (100)

*Injury occurred while working in agriculture and caused the subject to seek medical attention or lose at least one-half day of work or school time or have at least one-half day of restricted activity.
[a]Body parts affected by injury were categorized using the Occupational Injury and Illness Classification Manual [US Department of Labor, 2007].

uncovered pick-up truck in the past 12 months and non-use of seatbelts were significantly associated in step-wise fashion with increased risk. There was also a significant trend between risky attitudes toward farm safety and injury. Although injury risk was quantitatively comparable between boys and girls, animal-related injuries were more common among girls, and motor vehicle and machine- or tool-related injuries were more common among boys. The severity of the injuries is noteworthy, including fractures, burns, concussions, and traumatic amputation. The causes and mechanisms of the injury—chiefly animals, machinery, falls, and motor vehicles—could easily have been fatal in some cases.

Injury risk in this group of adolescents was higher than that seen in other adolescent groups living or working on farms. Hendricks and Hendricks [2010] reviewed data from the National Institute for Occupational Safety and Health (NIOSH) Childhood Agricultural Injury Survey

TABLE IX. External Cause of Injury Among 97 Rural California High School Students Reporting an Agricultural Injury* in the Preceding Year

		Frequency [n (%)]		
ICD9 E-code[a]	**External cause of injury**	**Boys**	**Girls**	**Total**
E818–E825.1	Injury related to motor vehicle	11 (15.5)	0 (0)	11 (11.3)
E828	Injury related to animal ride	0 (0)	7 (26.9)	7 (7.2)
E866.8	Poisoning by other solid or liquid substance	1 (1.4)	0 (0)	1 (1.0)
E844.9, E880–E888	Injury related to fall	10 (14.1)	2 (7.7)	12 (12.4)
E905.3	Wasp sting	1 (1.4)	0 (0)	1 (1.0)
E906.8	Specified injury caused by animal	12 (16.9)	12 (46.2)	24 (24.7)
E916–E917	Injury by striking	8 (11.3)	5 (19.2)	13 (13.4)
E919–E920	Injury by machine or hand tool	12 (16.9)	0 (0)	12 (12.4)
E924	Injury by burn	5 (7.0)	0 (0)	5 (5.2)
E926.2	Exposure to arc lamp radiation	3 (4.2)	0 (0)	3 (3.1)
E927	Lifting injury	6 (8.5)	0 (0)	6 (6.2)
E928.8	Other environmental accident, specified	1 (1.4)	0 (0)	1 (1.0)
	Other	1 (1.4)	0 (0)	1 (1.0)
	Total	71 (100)	26 (100)	97 (100)

*Injury occurred while working in agriculture and caused the subject to seek medical attention or lose at least one-half day of work or school time or have at least one-half day of restricted activity.
[a]Ninth Revision, International Classification of Diseases [World Health Organization, 1977].

(CAIS) and reported 1-year cumulative incidence for injury of 1.3% for boys and 0.6% for girls in 2006. Our results represent an approximate sixfold increase over the national CAIS figures, and the reasons for this are unclear. Observed rates may have been affected by method of data collection: our data came directly from the adolescents, whereas the CAIS involved a telephone interview with head of household, and children were interviewed if they were at least 16 years of age and available for interview. Thus, heads of household may not recall injuries as well as the involved child, leading to underestimation. Indeed, other studies using the teenager as respondent have found self-reported injury rates among farm youth exceeding those we report here [Schulman et al., 1997; Parker et al., 2002]. Also, injury risk may in fact be higher on the California farming operations in our study compared to the broader national sample comprising the CAIS.

We also noted a lower risk of injury in Hispanic youths compared to Whites. This is contrary to findings by other investigators. Bonauto et al. [2003] conducted a telephone survey of Washington state youth working on farms and noted increased risk for Hispanics. Hispanic youth in our study were less likely to perform hazardous tasks and were older at initiation with these tasks compared to Whites, and these factors may have contributed to their unexpectedly lower injury risk. In addition, Hispanic youth may have been less likely to report injuries than Whites.

We observed increased injury risk among participants working on large animal operations and performing selected farm tasks, in particular feeding large animals, mixing chemicals, and welding. Tractor driving was also associated with a near doubling of odds for injury, although this was of borderline significance ($P < 0.07$). Because the injuries were not restricted to those occurring during performance of these selected tasks, the tasks may represent a marker for other hazardous activities or attitudes toward work and safety. Study participants began these hazardous activities at an early age, for example, a median of 12 years for tractor driving and machinery use. Although this is younger than that recommended by the North American Guidelines for Children's Agricultural Tasks (NAGCAT) [National Children's Center for Rural Agricultural Health and Safety, 1998], it is not uncommon [Park et al., 2003]. The association between a simple three-question safety attitude index suggests this index may be useful for identifying persons at increased risk. Subjects with the highest scores, over 17% of the sample, manifested a more than doubling of odds for injury. Risky attitudes were also associated with injury in a national study involving a similar population of youth [Westaby and Lee, 2003; Lee et al., 2004].

There was a marked difference in injury characteristics between girls and boys. Nearly three-quarters of injuries among girls were related to animals, whereas boys were much more likely to be injured with motor vehicles or machinery, consistent with the finding that girls were more likely than boys to be involved in feeding animals. This difference in external cause may explain why girls were more likely than boys to suffer fractures and contusions. Similar findings have been reported by other investigators [Dimich-Ward et al., 2004; Erkal et al., 2009].

Strengths of this study include the relatively large number of participants and high participation rate, particularly after changing from an active (''opt-in'') to a passive (''opt-out'') informed consent process, and its geographic scope involving 10 public high schools in California's Central Valley. Limitations include the fact that we limited study to public high school students and did not select schools randomly from a comprehensive statewide list of schools, but rather focused on those in a highly agricultural area of California. Thus, the results may not apply to private high school-age students, to other areas of the nation or state, or to adolescents not in school.

The most important limitation is that we rely on questionnaire data that we were unable to validate. We believe exposure information, such as demographic and farm characteristics, is likely to be accurate, although estimates of time spent in various tasks may not be. Injury information, which depended on the participant to recall an approximate date and the circumstances of injury, may not be valid in some cases, such as for minor injuries. Thus, our results may underestimate true injury experience.

While the burden of child agricultural injury weighs heavily, especially on the individuals and families affected, national epidemiologic data show a significant reduction in childhood farm injury since at least 1998, especially for males. The CAIS shows a linear decrease in national farm injury trends among boys from 1998 to 2006, representing a 36% decline from 20.2 to 12.9 per 1,000 [Hendricks and Hendricks, 2010]. Girls experienced little change over this period (6.9–6.5 per 1,000), but had lower overall risk than boys. The observed reduction may be due to increased focus on childhood farm injury by the Centers for Disease Control and Prevention, including NIOSH, non-governmental organizations such as Farm Safety 4 Just Kids, and researchers. The National Children's Center for Rural Agricultural Health and Safety efforts to develop and promote the NAGCAT and Creating Safe Play Areas on Farms also likely play an important role [National Children's Center for Rural Agricultural Health and Safety, 1998; Esser et al., 2003]. Most importantly, this finding may augur a cultural shift occurring among farm owners and parents to end unsafe traditions involving farm work and children.

Despite indications of a trend toward reduced child agricultural injuries, there is a continuing search for effective prevention. Prevention classically has involved

engineering approaches, regulatory measures, and education. The most obvious means for reducing agricultural injury among adolescents is to limit their involvement in farm work, and in particular hazardous tasks. Marlenga et al. [2007] surveyed 1,193 Midwestern farm families and determined that approximately one-third of reported childhood injuries involved children working outside age-related requirements of the US Federal Child Labor Laws, Hazardous Occupations Orders for Agriculture, from which family farms are exempted. The authors suggest that removing the family farm exemption and raising the age for hazardous work to 18 from 16 would be effective in reducing childhood agricultural injury. Larson-Bright et al. [2007] observed increased risk among youth performing tasks at ages 2–3 years younger than recommended; there was a stepwise increase in risk for increased number of chores and farm work hours.

The effectiveness of education in preventing injury is unclear. Our results show a counterintuitive stepwise increase in injury risk with increasing number of agricultural science courses taken. However, this was not statistically significant, and it is likely influenced by confounding, that is, persons taking more classes in agriculture are also likely to have more exposure to agricultural risk compared to those taking fewer courses. Although we attempted to control for this by including in our model yearly hours worked in agriculture, residual confounding could still be present. Rautiainen reviewed extant literature and determined that there was little evidence of effectiveness for educational injury-prevention programs [Rautiainen et al., 2008]. Although some studies have shown gains in knowledge and intention for behavioral change [Teran et al., 2008], associated reductions in injury experience have not been demonstrated. Education is arguably necessary, albeit alone it appears insufficient for injury reduction.

Education with periodic follow-up may provide some reduction for youth farm injury. A NAGCAT educational session with quarterly surveillance telephone contacts was effective in reducing childhood farm injury in a randomized trial on 845 New York State farms involving over 2,400 children [Gadomski et al., 2006]. Approximately half of the 185 injuries observed over 21 months involved NAGCAT guidelines, and, of these, approximately half were deemed to have been preventable had NAGCAT guidelines been observed. The intervention group showed statistically significant lower risk for NAGCAT-preventable injuries (hazard ratio 0.52; 95%CI: 0.29, 0.92) and nonsignificant risk reductions for all injuries and NAGCAT-related injuries.

Our data suggest the importance of a parental role in injury prevention. Regarding the father as the most important source of safety information was associated with a nearly 50% reduction in odds of injury, although this was not statistically significant. In addition to education, parents may also limit work hours and hazardous activities inappropriate for the child's age, which are likely to be the most effective protective measures. Over one-fifth of subjects reported working more than 1,500 hr/year, an average of 30 hr/week, and increased injury risk may be due to fatigue and lack of sleep as well as increased exposure [Stallones et al., 2006]. Limitations on farm work may be difficult to implement in a culture that values work and self-reliance, even for children, and where regulatory requirements and enforcement are at a low level. Nevertheless, these data and those of other investigators argue for a stronger regulatory regimen, such as incorporating NAGCAT guidelines. Yet educational efforts will be a necessary part of any injury reduction programs, and our findings suggest that educational efforts should be focused on the most hazardous activities, which these data indicate are animal-related activities, especially among girls, and use of motor vehicles and machinery, especially among boys. Further research should focus on effectiveness of educational programs in reducing injury risk.

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