



## Increased Risk of Agricultural Injury among African-American Farm Workers from Alabama and Mississippi

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Research on the epidemiology of agriculture-related injuries has largely ignored African-Americans and farm workers. This cohort study is the first to estimate injury rates and to evaluate prospectively risk factors for agriculture-related injuries and compare them among African-American and Caucasian farmers and African-American farm workers. A total of 1,246 subjects (685 Caucasian owners, 321 African-American owners, and 240 African-American workers) from Alabama and Mississippi were selected from Agricultural Statistics Services databases and other sources and were enrolled between January 1994 and June 1996. Baseline data included detailed demographic, farm and farming, and behavioral information. From January 1994 to April 1998, subjects were contacted biannually to ascertain the occurrence of an agriculture-related injury. Injury rates were 2.9 times (95% confidence interval (CI): 2.0, 4.3) higher for African-American farm workers compared with Caucasian and African-American owners. Part-time farming (relative risk (RR) = 2.0, 95% CI: 1.3, 2.5), prior agricultural injury (RR = 1.5, 95% CI: 1.0, 2.1), and farm machinery in fair/poor condition (RR = 1.8, 95% CI: 1.2, 2.7) were also independently associated with injury rates. The results demonstrate the increased frequency of agricultural injury among farm workers and identify a number of possible ways of reducing them. *Am J Epidemiol* 2000;152:640–50.

accidents; agriculture; Blacks; injuries, poisonings, and occupational diseases

Incidence rates of fatal and nonfatal agricultural injury have not been extensively reported except retrospectively (1–12). Most studies have focused only on specific types of injuries (e.g., machinery related) or selected populations of farmers (e.g., owners) (7–23), and only one study has calculated rates accounting for exposure opportunity (13). There have been no studies wherein sufficient numbers of African-American farm owners and workers have been included to obtain valid estimates of injury rates. This is particularly important since a study of fatal agricultural injuries did report elevated rates among African Americans, particularly farm laborers (24). Although preventive efforts might benefit from knowing whether safety knowledge and safety behaviors are important determinants of agricultural injury, only a few stud-

ies have evaluated them as potential risk factors (14–16), and the majority of these studies have been cross-sectional.

This paper presents the results of a prospective study of risk factors for agriculture-related injuries among farmers and farm workers from five rural counties in Alabama and four rural counties in Mississippi, all with high proportions of African Americans. The objective of this paper is to estimate injury rates and to evaluate risk factors (specifically safety knowledge and behavior) for agriculture-related injuries overall and within specific samples of Caucasian and African-American farm owners and African-American farm workers. Not only is this the first paper to report results from a long-term prospective study, but it is also the first study to include African-American owners and workers and to evaluate a large number of potential risk factors.

### MATERIALS AND METHODS

#### Study subjects

The details of recruitment have been described previously (22). Briefly, between January 1994 and June 1996, subjects were recruited into the study. The catchment area for the study was nine rural counties in Alabama and Mississippi. In order to ensure sufficient representation of Black farmers and farm workers, recruitment was limited to rural counties with large Black populations (50 percent Black). Five counties from Alabama (Greene, Hale, Lowndes, Marengo, and Sumter) and four counties from Mississippi (Bolivar, Holmes, Humphreys, and Panola) were selected.

Received for publication April 21, 1999, and accepted for publication December 27, 1999.

Abbreviations: CI, confidence interval; RR, relative risk.

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Questionnaires were sent out to all 2,827 farm owners and operators (for simplicity we will call both operators and owners "owners") in these counties identified in a database maintained by the Alabama and Mississippi Agricultural Statistics Services. This database is used by the US Department of Agriculture for collecting data on livestock, growing crops, stored commodities, farm production, and farm expenses. It is continually updated and uses quality control measures, including on-site enumeration, reinterviews, list matching with other sources, and recontact on a continuous basis. A total of 1,950 farmers on the list (69.0 percent) were able to be located. Of these, 550 farmers were excluded because they were retired or deceased. Of those remaining ( $n = 1,400$ ), questionnaires were completed by 1,092 farmers (78 percent of those contactable and engaged in active farming).

There were no lists of farm workers that we were able to identify. Therefore, a variety of sources, including county agricultural agents, farm associations, schools, churches, and referrals given by farm operators and other farm workers connected with the study, were utilized to recruit and enroll 594 farm workers.

Baseline data were collected from a total of 1,686 active farmers and farm workers. Three hundred two subjects were not included in this follow-up analysis because their address or telephone number or both could not be verified. This precluded our ability to recontact them to ascertain injury outcomes. For the analyses presented in this paper, females ( $n = 122$ ) and Caucasian farm workers ( $n = 16$ ) were excluded as there were too few of either for meaningful analyses. Therefore, this paper is restricted to 1,246 subjects (685 Caucasian owners, 321 African-American owners, and 240 African-American workers).

During the follow-up period from January 1994 to April 1998, subjects were contacted biannually (July, January) to ascertain the occurrence and nature of an agriculture-related injury in the prior 6-month period. The percent follow-up rates per 6-month follow-up time among those who were able to be located at the first 6-month follow-up were as follows: 98 percent, 12 months; 97 percent, 18 months; 97 percent, 24 months; 85 percent, 30 months; 73 percent, 36 months; 61 percent, 42 months; 57 percent, 48 months. These values represent the proportion of subjects with whom we could establish contact at each biannual follow-up. Subjects who had died, stopped farming, or retired from farming were considered followed up as we were able to establish their status with respect to farming. The average duration of follow-up for the cohort was 2.5 years (median, 2.8 years; minimum, 0.1 year; maximum, 4.0 years). There were no differences in follow-up according to race or operator status. At the time of last contact, 1,091 were still actively farming, 83 had stopped farming but continued to be employed in other occupations, 31 had retired, and 41 were deceased (two deaths (0.16 percent) were directly attributable to farming).

#### Data collection

Subjects who gave written consent to participate in the study were asked to complete a baseline questionnaire. The

baseline questionnaire contained detailed demographic (e.g., age, race, education), farm and farming (e.g., commodities, safety training, equipment use), and behavioral (e.g., risk taking, alcohol consumption) information. In addition, subjects were asked to report the number of hours per week dedicated to farm-related work overall and by farming activity (e.g., machinery operation, livestock handling) for each month of the year. The baseline survey also collected information regarding previous farming-related injuries.

A follow-up questionnaire was administered in December 1996. The information collected was complementary to that collected at baseline but also included additional information. Analyses revealed that there was little or no difference in the follow-up and baseline measurements; therefore, the latter will be used in the analyses reported in this paper.

To ascertain the occurrence of injuries, subjects were asked at each 6-month follow-up if they experienced "an unintentional physical injury or poisoning which occurred during an agricultural activity and which required medical attention or resulted in at least one-half day of restricted activity." Intentional or domestic injuries and other injuries not related to agricultural activities were excluded. Subjects who responded affirmatively to the question were queried further regarding the nature and circumstances of the injury.

For each subject two measures of study duration were calculated. The first measure, "person-years," was the amount of chronologic time accrued between enrollment in the study and the occurrence of an injury, death, farming cessation, retirement, date of last follow-up (for those subjects lost to follow-up), or the study end date, whichever came first. Because this measure may not accurately reflect the amount of time spent farming, the amount of time each subject spent farming ("farming hours") was calculated as the number of hours doing work from the time of enrollment until injury occurrence or censoring (e.g., death, retirement). This was possible because information was obtained in the baseline questionnaire as to how many hours per week per month each farmer spent doing farm work.

#### Data analysis

To identify significant, independent determinants of injury occurrence, we used Cox proportional hazards modeling. An event is defined as the first occurrence of an injury during the follow-up period. Subjects who did not experience an injury, died, stopped farming, retired, or were lost to follow-up were censored at the time of last follow-up. The term "farming hours" was used as the time variable in these models.

To identify significant, independent associations between injury occurrence and sociodemographic, farm, and farm safety characteristics, we used a stepwise procedure. All variables of interest were candidates for inclusion in the selection process. Only those variables demonstrating a significant independent association at the  $\alpha = 0.05$  level were retained in the final model. For race- and farm ownership-specific models, any variable that was univariately significant in any group, as well as those which are significant

univariately in the overall cohort, was included in a multi-variable model.

**RESULTS**

Slightly over half (55.0 percent) of the subjects were Caucasian owners; 25 percent, African-American farm own-

ers; and nearly 20 percent, African-American farm workers. Table 1 presents the characteristics of the sample overall and by race and occupation. African-American farm workers were significantly younger, less well educated, and less likely to have a chronic medical condition than were either African-American owners or Caucasian owners. Caucasian owners were significantly more likely to be full-time farm-

**TABLE 1. Characteristics of study cohort by race and farm ownership, Alabama and Mississippi, 1994–1996**

Characteristic	Caucasian owners (n = 685)		African-American owners (n = 321)		African-American workers (n = 240)		Total	
	No.	%	No.	%	No.	%	No.	%
<b>Sociodemographic characteristics</b>								
<b>Age (years)</b>								
<40	113	16.7	41	13.0	130	54.2	284	23.0
40–49	157	23.1	68	21.6	66	27.5	291	23.6
50–59	166	24.5	71	22.5	22	9.2	259	21.0
≥60	242	35.7	135	42.9	22	9.2	399	32.3
				0.13*		0.001*		0.001†
<b>Education</b>								
<High school	70	10.2	122	38.1	118	49.8	310	24.9
High school	290	42.3	105	32.8	104	43.9	499	40.2
>High school	325	47.4	93	29.1	15	6.3	433	34.9
				0.001		0.001		0.001
<b>Full-time farming‡</b>								
No	378	55.2	256	79.8	176	73.3	810	65.0
Yes	307	44.8	65	20.3	64	26.7	436	35.0
				0.001		0.001		0.07
<b>Full-time other job</b>								
No	499	72.9	237	73.8	234	97.5	970	77.8
Yes	186	27.2	84	26.2	6	2.5	276	22.2
				0.74		0.001		0.001
<b>Medical conditions</b>								
None	277	40.9	145	45.5	183	77.2	605	49.0
Any	401	59.1	174	54.5	54	22.8	629	51.0
				0.17		0.001		0.001
<b>Prior agricultural injury</b>								
No	486	71.0	274	85.4	192	80.0	952	76.4
Yes	199	29.0	47	14.6	48	20.0	294	23.6
				0.001		0.01		0.09
<b>Alcohol consumption (ml/week)</b>								
None	410	62.1	232	74.8	117	52.0	759	63.5
>0–99	139	21.1	51	16.5	37	16.4	227	19.0
≥100	111	16.8	27	8.7	71	31.6	209	17.5
				0.001		0.001		0.001
<b>Farm characteristics</b>								
<b>Farm size (acres)§</b>								
<200	196	29.0	219	69.8	28	12.2	443	36.3
≥200	481	71.1	95	30.3	201	87.8	777	63.7
				0.001		0.001		0.001

Table continues

TABLE 1. Continued

Characteristic	Caucasian owners (n = 685)		African-American owners (n = 321)		African-American workers (n = 240)		Total	
	No.	%	No.	%	No.	%	No.	%
Primary commodity farmed								
Field crops	209	30.5	133	41.4	200	83.3	542	43.5
Livestock	279	40.7	99	30.8	10	4.2	388	31.1
Forestry	19	2.8	7	2.2	6	2.5	32	2.6
Aquaculture	47	7.0	5	1.6	12	5.0	65	5.2
Vegetables	4	1.0	4	1.3	0	0.0	8	1.0
Mixed	114	16.6	67	20.9	10	94.2	191	15.3
Other	12	1.8	6	1.9	2	1.0	20	1.6
				0.01		0.001		0.001
No. of farm machines								
0–5	122	17.8	131	40.8	109	45.4	351	28.4
6–10	175	25.5	104	32.4	81	33.8	360	29.1
11–15	176	25.7	52	16.2	19	7.9	247	20.0
16–41	212	30.9	34	10.6	31	12.9	277	22.4
				0.01		0.001		0.009
Tractor use								
No	47	7.0	42	13.2	45	19.0	134	10.9
Yes	629	93.1	276	86.8	191	80.9	1,096	89.1
				0.001		0.001		0.05
Condition of farm machinery								
Excellent/good	568	84.8	202	66.5	202	86.0	972	80.4
Fair/poor	102	15.2	102	33.6	33	14.0	237	19.6
				0.001		0.06		0.001
Farm safety characteristics								
Wear seatbelt on farm machinery								
Always	244	35.6	187	58.3	129	53.8	560	44.9
Sometimes	127	18.5	63	19.6	71	29.6	161	20.9
Never	314	45.8	71	22.1	40	16.7	737	34.1
				0.001		0.001		0.02
Turn off machinery								
Always	400	60.5	193	65.6	156	70.3	749	63.6
Sometimes	225	34.0	86	29.3	61	27.5	372	31.6
Never	36	5.4	15	5.1	5	2.3	56	4.8
				0.12		0.01		0.22
Drive equipment on roadways								
No	119	17.7	91	29.6	91	39.4	301	24.9
Yes	552	82.3	216	70.4	140	60.6	908	75.1
				0.001		0.001		0.03
Hurry when farming								
Sometimes/rarely	447	66.6	256	81.0	199	85.0	902	73.9
Frequently	224	33.4	60	19.0	35	15.0	319	26.1
				0.001		0.001		0.20

Table continues

ers (40 hours spent farming per week) and to have experienced at least one agriculture-related injury in the past than

either other group. No alcohol consumption was reported by the majority in all three groups; however, African-American

TABLE 1. Continued

Characteristic	Caucasian owners (n = 685)		African-American owners (n = 321)		African-American workers (n = 240)		Total	
	No.	%	No.	%	No.	%	No.	%
Tired when farming								
Sometimes/rarely	501	74.4	253	79.8	177	74.4	931	75.8
Often	172	25.6	64	20.2	61	25.6	297	24.2
				0.06		0.98		
						0.12		
Farm safety training								
Any	344	51.4	181	58.0	137	58.3	662	54.4
None	325	48.6	131	42.0	98	41.7	554	45.6
				0.05		0.07		
						0.87		
Attention level of safety								
Very attentive	446	66.6	241	76.3	171	71.9	858	70.1
Attentive/not attentive	224	33.4	75	23.7	67	28.2	366	29.9
				0.002		0.13		
						0.24		
Attitude toward safety								
Very careful	529	78.7	266	83.9	196	82.0	991	80.7
Somewhat/not careful	143	21.3	51	16.1	43	18.0	237	19.3
				0.06		0.30		
						0.55		

\* *p* for comparison with Caucasian owners.

† *p* for comparison between African-American workers and owners.

‡ Greater than or equal to 40 hours per week.

§ Two hundred acres equal 80.94 ha.

workers drank significantly more than did Caucasian owners, who drank significantly more than did African-American owners.

With respect to farm characteristics, significantly more African-American workers worked on farms of 200 acres (80.94 ha) or more than did either other group. The most common types of commodities farmed were field crops and livestock. African-American workers were much less likely to work with animals. Caucasian owners were significantly more likely to use tractors than was either other group. African-American owners were significantly more likely to report their machinery condition as only fair to poor.

With respect to safety practices and behaviors, consistent use of seatbelts on farm machinery and being very attentive to farm safety were significantly less common, and driving equipment on public roadways and frequently hurrying,

more common among Caucasian owners. African-American workers were significantly more likely to report always turning off farm machinery when attempting to dislodge something that had become stuck.

Between January 1994 and January 1998, the study cohort had accumulated over 5 million hours of agriculture-related work over 3,227 person-years of follow-up. During the same period, a total of 140 injuries were reported among 131 subjects (table 2). The overall crude injury rate was 24.5 per million farming hours (4.1 per 100 person-years). African-American workers had a significantly ( $p < 0.001$ ) higher rate of 59.7 per million farming hours than did either other group, followed by African-American owners and Caucasian owners, whose rates were 25.9 and 18.2 per million farming hours, respectively. Compared with Caucasian owners, injury rates were 3.3 times (95 percent confidence

TABLE 2. Injury rates by race and farm ownership, Alabama and Mississippi, 1994–1996

	No. of subjects	No. injured	No. of injury episodes	No. of person-years	No. of farming hours	Injury rate/100 person-years	Injury rate/1 million farming hours
Caucasian owners	685	67	70	2,047	3,688,138	3.3	18.2
African-American							
Owners	321	27	30	821	1,043,517	3.3	25.9
Workers	240	37	40	359	619,324	10.3	59.7
Total	1,246	131	140	3,227	5,350,979	4.1	24.5

interval (CI): 2.2, 4.9) higher among African-American workers; no significant increase was observed for African-American owners (relative risk (RR) = 1.4, 95 percent CI: 0.9, 2.2). African-American farm workers were also more

likely to classify their injuries as serious (50.0 percent) compared with Caucasian and African-American owners (22.9 percent and 32.3 percent, respectively). However, the two deaths directly attributable to farming occurred among

**TABLE 3. Race- and farm ownership-stratified crude and overall adjusted relative risks (RRs) and 95% confidence intervals (CIs), Alabama and Mississippi, 1994–1996**

Characteristic	Caucasian owners		African-American owners		African-American workers		Overall	
	RR*	95% CI	RR*	95% CI	RR*	95% CI	RR†	95% CI
<b>Sociodemographic characteristics</b>								
Age (years)								
<40	1.0	Reference	1.0	Reference	1.0	Reference	1.0	Reference
40–49	1.0	0.5, 2.3	0.5	0.1, 2.0	0.4	0.2, 0.9	0.6	0.4, 1.0
50–59	1.2	0.6, 2.5	0.5	0.1, 1.7	0.9	0.3, 2.2	0.8	0.5, 1.3
≥60	1.3	0.6, 2.5	1.0	0.4, 2.7	0.1	0.1, 0.9	0.8	0.5, 1.3
Education								
<High school	1.0	Reference	1.0	Reference	1.0	Reference	1.0	Reference
High school	0.9	0.4, 2.0	0.6	0.2, 1.3	0.8	0.4, 1.6	0.7	0.5, 1.1
>High school	1.1	0.5, 2.5	0.3	0.1, 1.0	1.4	0.4, 4.5	0.8	0.5, 1.3
Full-time farming‡								
No	1.0	Reference	1.0	Reference	1.0	Reference	1.0	Reference
Yes	0.4	0.2, 0.6	0.8	0.3, 1.7	0.8	0.4, 1.5	0.5	0.4, 0.8
Full-time other job								
No	1.0	Reference	1.0	Reference	1.0	Reference	1.0	Reference
Yes	2.2	1.2, 3.7	0.7	0.3, 2.0		§	1.5	1.0, 2.4
Prior agricultural injury								
No	1.0	Reference	1.0	Reference	1.0	Reference	1.0	Reference
Yes	1.4	0.8, 2.2	0.6	0.2, 2.0	1.9	1.0, 3.9	1.4	0.9, 2.0
<b>Farm characteristics</b>								
Farm size (acres)¶								
<200	1.0	Reference	1.0	Reference	1.0	Reference	1.0	Reference
≥200	0.5	0.3, 0.9	1.1	0.5, 2.3	3.2	0.8, 13.5	0.9	0.6, 1.4
Primary commodity farmed								
Field crops	1.0	Reference	1.0	Reference	1.0	Reference	1.0	Reference
Livestock	3.7	1.8, 7.4	1.1	0.4, 2.9		§	1.9	1.2, 2.9
Forestry		§	2.2	0.3, 17.4		§	0.5	0.1, 3.5
Aquaculture	1.7	0.5, 5.5		§	0.5	0.1, 3.9	0.9	0.3, 2.2
Mixed	3.2	1.5, 7.1	1.5	0.6, 3.8	1.0	0.2, 4.2	1.8	1.1, 3.0
Other	4.8	1.1, 21.9		§		§	1.1	0.3, 4.6
Condition of farm machinery								
Excellent/good	1.0	Reference	1.0	Reference	1.0	Reference	1.0	Reference
Fair/poor	1.6	0.8, 3.0	1.7	0.8, 3.9	2.4	1.2, 5.0	1.8	1.2, 2.7
<b>Farm safety characteristics</b>								
Wear seatbelt on farm machinery								
Always	1.0	Reference	1.0	Reference	1.0	Reference	1.0	Reference
Sometimes	0.3	0.1, 0.8	1.0	0.4, 2.7	1.1	0.5, 2.4	0.6	0.4, 1.0
Never	0.8	0.5, 1.3	0.8	0.3, 2.3	1.7	0.7, 4.1	0.9	0.6, 1.3
Turn off machinery								
Always	1.0	Reference	1.0	Reference	1.0	Reference	1.0	Reference
Sometimes	1.0	0.6, 1.7	0.4	0.1, 1.0	1.2	0.6, 2.4	0.9	0.6, 1.3
Never	1.7	0.8, 3.9	0.7	0.1, 5.1	1.2	0.3, 5.0	1.4	0.7, 2.6
Drive equipment on roadways								
No	1.0	Reference	1.0	Reference	1.0	Reference	1.0	Reference
Yes	1.6	0.7, 3.7	1.7	0.6, 5.1	0.7	0.3, 1.3	1.0	0.7, 1.5

Table continues

TABLE 3. Continued

Characteristic	Caucasian owners		African-American owners		African-American workers		Overall	
	RR*	95% CI	RR*	95% CI	RR*	95% CI	RR†	95% CI
Hurry when farming								
Sometimes/rarely	1.0	Reference	1.0	Reference	1.0	Reference	1.0	Reference
Frequently	1.3	0.8, 2.1	1.0	0.4, 2.6	0.9	0.4, 2.1	1.2	0.8, 1.7
Tired when farming								
Sometimes/rarely	1.0	Reference	1.0	Reference	1.0	Reference	1.0	Reference
Often	0.8	0.5, 1.5	1.6	0.7, 3.6	1.3	0.7, 2.6	1.1	0.7, 1.6
Farm safety training								
Any	1.0	Reference	1.0	Reference	1.0	Reference	1.0	Reference
None	1.7	1.0, 2.8	1.3	0.6, 2.9	0.9	0.5, 1.9	1.4	1.0, 2.0
Attention level of safety								
Very attentive	1.0	Reference	1.0	Reference	1.0	Reference	1.0	Reference
Attentive/not attentive	2.0	1.2, 3.3	0.2	0.1, 1.0	0.9	0.5, 1.8	1.2	0.8, 1.7
Attitude toward safety								
Very careful	1.0	Reference	1.0	Reference	1.0	Reference	1.0	Reference
Somewhat/not careful	1.6	1.0, 2.8	0.2	0.1, 1.7	1.3	0.6, 2.6	1.2	0.8, 1.9

\* Crude.

† Adjusted for race/farm ownership.

‡ Greater than or equal to 40 hours per week.

§ Undefined.

¶ Two hundred acres equal 80.94 ha.

Caucasian owners. Nearly 80 percent (79.6 percent) of farmers injured required medical attention for their injuries, and over 20 percent (23.7 percent) required inpatient care. There were no important differences among the three groups with respect to the proportions requiring medical attention and those requiring inpatient care.

Table 3 presents the race- and farm ownership-stratified crude and overall race and farm ownership status-adjusted relative risks and 95 percent confidence intervals for the potential risk factors evaluated. Overall full-time farmers had a significantly lower rate (RR = 0.52, 95 percent CI: 0.32, 0.85). Lower rates were present in full-time farmers in all three groups and significantly lower among the Caucasian owners. Conversely, those who had another full-time job were more likely to have an injury; this was specifically notable among the Caucasian owners. There was of course considerable overlap among those who farmed less than full-time and those who had another full-time job. There were no strong associations with respect to age, education, or having a medical condition. Overall, those with a prior agricultural injury had a 40 percent increase in rate; African-American workers with a prior injury had almost double the rate. Although there was no association overall with alcohol consumption, African-American owners consuming  $\geq 100$  ml per week had higher rates compared with nondrinkers (RR = 2.1, 95 percent CI: 0.7, 6.2).

Several farm characteristics were also associated with injury rates. Although there was no association overall with farm size, those Caucasian owners who own large farms ( $\geq 200$  acres or 80.94 ha) had significantly decreased risk (RR = 0.5, 95 percent CI: 0.3, 0.9) while African-American

workers who worked on large farms tended to have higher rates (RR = 3.2, 95 percent CI: 0.8, 13.5). Compared with those working with field crops, overall and among Caucasian owners, those working in livestock and mixed farming had significantly higher injury rates. Farmers whose machinery was in fair or poor condition had significantly elevated adjusted rates overall (RR = 1.8, 95 percent CI: 1.2, 2.7). This was found in all groups, significantly in African-American workers.

Overall, most farm safety characteristics were not significantly associated with injury rates, with the exception that those who did not have any farm safety training were at significantly increased risk. This was especially true among Caucasian owners. Moreover, Caucasian owners who reported less care toward safety (RR = 1.6, 95 percent CI: 1.0, 2.8) and being somewhat or not attentive to safety (RR = 2.0, 95 percent CI: 1.2, 3.3) had significantly elevated rates.

In the overall multivariable analyses, African-American workers, part-time farmers, those with a prior agricultural injury, and those who used farm machinery whose condition was described as fair to poor were at significantly increased risk (table 4). The factors that were significant independent predictors varied within race/ownership status. For Caucasian owners, those who were at significantly increased risk were part-time farmers, those who never turned off machinery, those who were less attentive to safety and livestock, and those who were mixed farmers; for African-American owners, only those who were attentive to safety; for African-American workers, those who worked on larger farms and those who used machinery that was described as being in only fair-to-poor condition.

**TABLE 4. Multivariable results for all subjects and by race and farm ownership, Alabama and Mississippi, 1994–1996**

Characteristic	RR*,†	95% CI*
<i>All subjects</i>		
Race and farm ownership		
Caucasian owner	1.0	Reference
African-American owner	1.3	0.7, 2.2
African-American worker	3.4	1.8, 6.3
Full-time farming		
No	1.0	Reference
Yes	0.5	0.4, 0.8
Prior agricultural injury		
No	1.0	Reference
Yes	1.5	1.0, 2.1
Condition of farm machinery		
Excellent/good	1.0	Reference
Fair/poor	1.8	1.2, 2.7
<i>Caucasian owners</i>		
Full-time farming		
No	1.0	Reference
Yes	0.5	0.3, 0.8
Turn off machinery		
Always/sometimes	1.0	Reference
Never	2.9	1.3, 6.6
Attention level to safety		
Very attentive	1.0	Reference
Attentive/not attentive	1.9	1.2, 3.2
Commodity farmed		
Other‡	1.0	Reference
Livestock	3.0	1.6, 5.8
Mixed	2.9	1.4, 6.2
<i>African-American owners</i>		
Attention level to safety		
Very attentive	1.0	Reference
Attentive/not attentive	0.2	0.1, 1.0
<i>African-American workers</i>		
Farm size (acres)§		
<200	1.0	Reference
≥200	3.7	1.0, 16.1
Condition of farm machinery		
Excellent/good	1.0	Reference
Fair/poor	3.7	1.8, 7.7

\* RR, relative risk; CI, confidence interval.

† Results of forward stepwise multivariable analyses; within each group, RRs and 95% CIs are adjusted for all other variables identified.

‡ Reference group is field crops, forestry, aquaculture, and other.

§ Two hundred acres equal 80.94 ha.

## DISCUSSION

The overall injury rate in this study was 24.5 per million farming hours. To our knowledge, only one other study has calculated injury rates using this metric; the rate reported in

that study (21.3 per million farming hours) is consistent with ours (13). Using the more common metric of person-years, the overall injury rate was 4.1 per 100 person-years; this rate is lower than those reported elsewhere that ranged from 5.0 to 13.9 per 100 person-years (3, 4, 6, 7, 13–15, 25). The lower rate observed in our study can be partly attributed to the fact that our farmers tend to work fewer hours than those in other studies. Therefore, when calculated on a person-year basis, the rates appear different, whereas once actual time spent farming is accounted for, the differences become negligible.

The injury rate among African-American farm workers was over three times that of Caucasian farm owners and almost twice that of African-American owners. Consistent with this finding, Richardson et al. (24) reported that age-adjusted fatal injury rates were 2.5 times higher among African-American farmers compared with Caucasian farmers. The only other studies wherein African-American farmers were included reported that African-American farm owners (4) and African-American farm workers (22) had lower nonfatal injury rates compared with Caucasian owners. However, these studies were both cross-sectional. One possible explanation for the difference is that African-American owners and farm workers are less likely to continue working at farming following an injury. Results from this study (not shown) are supportive of this. Although there was no difference in severity among the injuries reported by the three groups, African-American farm workers were much more likely to have persistent injuries and more days lost from work. While it did not specifically address African-American farm workers, the study by Lewis et al. (15), which found that those who worked on others' farms were at increased risk, reports results that are consistent with our finding. It has been suggested that differences in injury rates between African-American and Caucasian farmers can be attributed to differences in working conditions (e.g., type of farming) and demographic factors (e.g., alcohol consumption) (24). However, in the present study the elevated injury rates persisted after adjusting for these and all other factors. It is possible, however, that our assessment of work practices did not fully capture the more dangerous nature of the work being done by African-American farm workers.

Full-time farmers were found to be at reduced risk of injury. Zhou and Roseman (4) also reported lower injury rates for full-time farmers. Contrary to these findings, Browning et al. (5) did not find that full-time farmers had lower injury rates, and Crawford et al. (14), Brison and Pickett (6, 12), and the cross-sectional baseline results from the present study (22) reported significantly higher rates for full-time farmers. The probable explanation for the discrepant findings is that full-time farmers have more opportunity for injury, that is, more exposure time (e.g., hours spent farming). In fact, Nordstrom et al. (13) found that after calculating injury rates per hour spent farming full-time farmers had lower injury rates compared with part-time farmers, whereas the opposite conclusion is reached when person-years are used. Similarly, in the present study if person-years are used rather than farming hours as denominators for injury rates, full-time farmers have higher injury

rates compared with part-time farmers. The question remains as to why full-time farmers have lower rates of injury per farming hour. We had hypothesized that part-time farmers would be more likely to be involved in an injury because they would be more tired if they had other jobs, would be more hurried to finish their farm work, and have poorer equipment; however, the differences remained significant even after adjusting for these factors. It was also possible that full-time farmers had lower rates because they were more likely to have workers working for them who did the more dangerous work. However, controlling for the presence of workers did not change the results.

Farmers who reported prior agriculture-related injuries were more likely to have experienced subsequent injuries, a finding consistent with most (4, 5, 21, 26) but not all (12) prior studies. One possible explanation is that disabilities resulting from previous injuries may predispose farmers to subsequent injuries. In support of this explanation, Lewis et al. (15) reported that farmers having an impairment that limits their work had increased risk of injury. Another possible explanation is that farmers experiencing prior injuries may work in more hazardous environments, take more risks, or generally be less conscious of safety issues. In the present study, after adjustment for factors such as safety training and attentiveness, equipment quality, and alcohol consumption, the association between previous and subsequent injuries was reduced and no longer significant, suggesting that the latter explanations are more likely. If this is the case, it suggests that the time immediately following an injury is the "teachable moment," the time to reinforce the need to reduce these risk factors for injury (5).

Equipment has been reported to be a frequent cause of farm injury (4, 5, 7, 13–15, 22, 27). Over 40 percent of injuries in the present study were associated with machinery or equipment, and approximately 15 percent of all injuries were directly attributed to equipment failure. Farmers who reported using farm equipment in fair or poor condition had significantly higher injury rates; this was particularly true for African-American farm workers. To our knowledge no other studies have evaluated the association between the fitness of farm equipment and injury occurrence. For farmers injured as a direct result of poor-quality equipment, the interpretation of these findings is quite clear. Failing or poor-quality equipment may be more likely to fail during normal operation, thereby placing the operator or those around the equipment at risk of injury. Furthermore, equipment in poor condition may require more maintenance and repair than well-functioning equipment, consequently placing farmers at risk of injury during these activities (8, 28). However, it is also possible that poor-quality equipment serves as an indicator of other factors that may place farmers at increased risk of injury (e.g., less interest in safety).

Of the few studies that evaluated safety behavior and training as risk factors for farm injury (14–16, 22), only one has found increased risk of injury among those who reported being somewhat or not attentive to farm safety (22). While the present results were consistent with this overall, among Caucasian farm owners, not turning off machinery to make repairs and being inattentive to safety were associated with

risk of injury. Although few injuries could actually be attributed to never turning off farm machinery, farmers who report this behavior may be at risk of injury for other possibly safety-related reasons. Surprisingly, we found that African-American owners who reported being less attentive to safety were at reduced risk of injury. Crawford et al. (14), who reported similar results, suggested that farm owners may not actually be doing the work on their farms and thus have little concern for safety. However, as noted previously, even when we adjusted for having employees on the farm, there was little impact on the association. The authors also suggested their results could be a result of the cross-sectional study design; that is, farmers who had been injured had adopted stronger safety attitudes. However, given that we found a similar result in our prospective study, this latter explanation appears unlikely.

Overall, farmers reporting no history of farm safety training had elevated injury rates, but this variable was not retained in the multivariate models. However, there was a strong association between attention to safety and safety training, especially among Caucasians. Since attentiveness is the more proximate factor (compared with training), it should not be surprising that the association with safety training disappeared following adjustment for attentiveness.

We also found that certain commodities (e.g., livestock, mixed) were associated with higher injury rates among Caucasian owners. This is consistent with prior research (5–7, 11–13, 29). Browning et al. (5) reported that beef cattle farmers had greater risk of injury compared with those in other commodities. Elkington (21) suggested that livestock farming tended to be the most time consuming and that injury risk increases with increasing hours of work; however, our results, which are adjusted for time farming, retain the difference. The specific characteristics that led to these increased injury rates remain to be identified. We found increased risk even after controlling for all the other factors we studied.

Although many other studies have found increased rates among farmers who work on larger farms (4, 7, 11, 22, 29–32), in our prospective study only African-American farm workers who are employed on large farms ( $\geq 200$  acres) had elevated injury rates compared with those working on smaller farms. One possible explanation for our lack of association among our Caucasian farmers is that African-American farm workers are working beside the farm machinery or doing the more hazardous work on the large farms.

There are a number of previously reported associations for which we found little evidence in our results. We did not find an association between age or greater cumulative years of farm work and injury rates; this result is in contrast to those of several other studies (4, 6, 14, 15) but is consistent with those of others (8, 10, 13, 22, 23). The difference may reflect the cross-sectional nature of the previous studies, since younger farmers and farm workers who become injured are more likely to leave farming. We also did not find an association with medical history, education, and alcohol consumption, but results from previous studies have not been convincing (4, 5, 8–10, 12, 14, 15, 17, 22, 23).

The results of this study should be interpreted in light of several limitations. First, all information was obtained via self-report, including the occurrence of injuries. However, Pratt et al. (11) found excellent agreement between self-reported injuries and emergency department records. Further, in the present study, farmers were asked to recall injuries that occurred within the past 6 months, not 12 months as in most other studies. Second, this study may not be generalizable to other farming groups, regions, or types of farming. Third, the African-American farm workers were not selected in a manner similar to farm owners and therefore may not be representative of African-American farm workers in Alabama and Mississippi. This was unavoidable since no validated roster of those farm workers is available. We think this is unlikely to bias our results given the prospective nature of the study. We can think of no reason why those African-American farm workers who agreed to participate would be selected for increased injury risk (they had lower baseline rates of prior injury) nor why their risk factor relations with subsequent injury would be distorted. Despite these limitations, because of the prospective nature of this study we were better able to estimate incidence rates and do so using a more appropriate measure of exposure than that used in most previous studies that did not take time actually farming into account. We were also able to keep losses to follow-up at a minimum, especially among such a difficult to follow group as farm workers. Finally, although information on safety behaviors was obtained without knowledge of subsequent injury, the accuracy of such reports is unknown. There may be substantial temptation to exaggerate the extent to which safety measures are taken because this may be assumed to be a desirable behavior.

In summary, this prospective study documented a significantly increased rate of agriculture-related injury among African-American farm workers and identified several farmer and farm characteristics associated with increased injury rates, specifically part-time farming, prior agricultural injury, and farm machinery in only fair to poor condition. These findings identify specific features of the farming environment (e.g., machinery) as well as subpopulations of farmers (e.g., African-American workers) that can serve as targets for injury prevention initiatives.

## ACKNOWLEDGMENTS

This study was made possible by grant R49/CCR408856 from the Centers for Disease Control and Prevention.

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