# Agricultural Work-Related Injuries Among Farmers in Hubei, People's Republic of China

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ABSTRACT

*Objectives.* This population-based study evaluated patterns of, and risk factors for, agricultural injuries among farmers in the People's Republic of China.

*Methods.* A multistage sample of 1500 Chinese farmers was selected from 14 villages. Face-to-face interviews with 1358 farmers were conducted between July 1997 and September 1997 (response rate=91%). Agricultural work-related injuries that occurred in the previous 24 months and the associated factors were evaluated.

*Results.* A total of 33% of the farmers reported at least 1 work-related injury in the 24 months before the survey. Major external causes of the injuries were hand tools (50%), falls (26%), and heavy falling objects (10%). The statistically significant risk factors for injury were low family income, 1 to 6 school years of education, self-reported pesticide exposure, tension in relationships with neighbors, and stress in life. The most notable result was the relation between self-reported pesticide exposure and injury, with farmers with greater pesticide exposure at significantly greater risk for injury.

*Conclusions.* The results of this study indicated that injuries occurring among Chinese farmers may have unique patterns and potential risk factors. (*Am J Public Health.* 2000;90:1269–1276)

The World Health Organization predicts that by the year 2020, injuries will be responsible for more death, morbidity, and disability than all communicable diseases combined.[1] Currently, injuries account for 1 in 7 potential life-years lost worldwide, but by 2020 they will account for 1 in 5, with the developing countries bearing the brunt of this increase.[1–3] Injury control has recently gained attention and enormous support with the infusion of funding for injury control in developed countries and particularly the creation of the National Center for Injury Control and Prevention within the Centers for Disease Control and Prevention in the United States.[2,4–7] During the last decade of the 20th century, workers in the US agriculture industry received particular attention because of the high risk of fatal injuries and suspected risk for serious nonfatal injuries.[6–8]

Previous studies of work-related injuries among farmers have described patterns of farmers' injuries and have evaluated a variety of potential risk factors.[6–18] In general, the risk factors have been categorized into 2 domains: physical characteristics of the farming environment and personal characteristics of the farmers. With respect to characteristics of the farming environment, the patterns of injury have been fairly consistently reported among these studies, with farm machinery, falls, and animal-related injuries being the 3 major external causes of injury.[6,7,9–15] Several studies reported that exposure to pesticide, particularly organophosphate and carbamate pesticide, was associated with increased risk of agricultural work-related injuries.[9,10,12,13,16] Although biologically plausible, the findings must be corroborated in larger studies.[10,12]

With respect to personal characteristics of the farmers, males were found to be at higher risk for injury than females, regardless of hours spent in farm activities.[7,17,18] Although results of several studies indicated that younger farmers have the highest risk of nonfatal injuries,[10,12–14,17] older farmers tend to account for the greatest proportion of agricultural fatalities.[17,19] Among 20 recently reviewed studies of stress and occupational injuries, all found a statistically significant association ($P \leq .05$) between stress and injuries, and 12 of the 17 studies with quantitative measures had odds ratios greater than 1.0, indicating that stress increased the risk of injuries.[20] Other factors such as education,[21] preexisting diseases and use of medications,[11–14] alcohol consumption,[9] family incomes,[8,11,13,14] and knowledge of safe practices and safety behaviors[13,22] also have been evaluated, but the conclusions have been inconsistent.

However, outside North America, western Europe, and Australia, information about injury problems and solutions is particularly sparse because the injury control efforts from communities and government in developing countries are well below the level of those directed at other health problems.[2,23–25] Although injury is receiving increasing attention as a public health problem in China, research efforts have focused on motor vehicle injuries.[25–27] Little investigation of work-related injuries among 800 million Chinese farmers has been done.[28]

This study examined the patterns of work-related injuries among Chinese farmers in Hubei Province, People's Republic of China.

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Of special interest were characteristics of the injuries and risk factors among Chinese farmers, including personal factors, family income, pesticide application patterns, and stress events.

## Methods

### *Study Design and Sampling*

This study used a multistage cluster sample of Chinese farmers in Hubei Province, which has 44 counties, 10 of which are in the agricultural area along the Youngtze River. Each county has 50 to 150 villages, and each village has approximately 50 households and 150 to 200 people. The government requires each village to keep a listing of each household in the village, as well as records of the name, sex, and age of family members. This listing is updated periodically by leaders residing in each village.

At the first stage, 3 counties in the Youngtze River area (Yichang, Shashi, and Jingshan) were selected with the assistance of the Provincial Bureau of Public Health. These counties are relatively uniform in soil types and major farming practices. The major agricultural products in these areas are rice, cotton, and vegetables. At the second stage, we used a systematic sampling method to select 14 villages in these 3 counties. Based on census data, villages in each county were ranked by size of the adult (15 years or older) population. We then used systematic sampling methods to select 5 villages from both Yichang and Shashi counties and 4 villages from Jingshan County. After the villages were chosen, the county department of public health contacted village leaders and obtained copies of the listings of households and family members.

In the summer of 1997, 21 students at the College of Public Health, Tongji Medical University, were trained as interviewers for this project. The questionnaire was developed by a research team at the Department of Preventive Medicine of Tongji Medical University. The questionnaire was designed to collect detailed information on basic personal characteristics, self-perceived health status, annual family income, pesticide application, pesticide poisonings, nonfatal work-related injuries, relationships among family members and neighbors, and stress in life. The questionnaire was pretested on a small group of farmers in the study area; minor changes were made to the questionnaire before the formal data collection.

Starting in July 1997, the interviewers, with help from village leaders, conducted face-to-face interviews with eligible individual farmers to collect data. The eligible farmers were defined as "any person of 15 years of age or older who has lived in the village since July 1995 whose primary occupation (75% of annual working hours) was farming." For those farmers who could not participate when the survey was conducted in that particular village, no follow-up was done because of time and resource limitations. Data collection was completed in September 1997. The questionnaires were returned to the research team at the Department of Preventive Medicine and were then checked by researchers.

### *Study Variables*

In this study, agricultural work-related injuries were defined as injuries that occurred during farmwork or farm chores between July 1995 and July 1997 and that resulted in a reduction in usual activities for more than half a day. This definition also included work-related injuries that occurred on another person's farm. Injuries sustained while farmers were working in other occupations, during recreational activities, in the home environment, or during travel unrelated to farmwork or chores were excluded. For farmers who had multiple injuries within that 2-year period, analyses were based on the most recent injury event.

Information on the external cause of the injury, the part of the body that was injured, the medical cost of the injury, and the days required to recover from the injury also was obtained from farmers who were injured.

Education years were divided into 4 categories (0, 1–6, 7–9, and 10–12 years). Annual income per family member was classified in 4 groups (<¥500, ¥500–999, and ≥¥1000 and unknown/refused; US $1.00≈¥8.33). The cases of pesticide poisonings were self-reported according to symptoms, whether medical help was sought, and the normal activity days missed because of the poisoning. Each participant was asked detailed information about pesticide applications, such as season of application, crops on which pesticides were applied, average number of pesticide applications per week during growing seasons (May to August each year), whether personal protective equipment was used during pesticide application, and whether a bath was usually taken after pesticide application. Self-perceived health status, tension in family member relationships and relationships with neighbors, and whether life was stressful were determined subjectively by participants, with the assistance of the interviewers. The guidelines on how to ask questions about those variables and how to select choices were provided to interviewers during the training sessions and were attached to the questionnaire during the formal investigations.

### *Statistical Analysis*

The SAS statistics package[29] was used in all data analyses. Our analysis was completed in 3 stages. First, we described the demographics of the sample and the percentage of injuries with regard to sex, age, school years, self-perceived health, family income, pesticide application and poisoning, tension in relationships with family and neighbors, and stress in life. Mantel-Haenszel $\chi^2$ tests for trend were computed, and the associated $P$ values were reported to compare injury rates between groups. Second, we analyzed the data on injuries according to primary external causes of the injury, the part of the body that was injured, the medical cost of the injury, and the days required to recover from the injury.

Third, we constructed logistic regression models to obtain estimated odds ratios and associated 95% confidence intervals. We calculated crude odds ratios and 95% confidence intervals by entering only single study variables into each logistic regression model as the independent variable and injury status as the dependent variable. We calculated adjusted odds ratios and 95% confidence intervals by including the following variables in the logistic models: sex, age, school years, self-perceived health, family income, pesticide exposure, and tension in relationships. To avoid collinearity,[30] we computed separate logistic regression models for each pesticide exposure variable when calculating adjusted odds ratios and 95% confidence intervals by putting the individual pesticide exposure variable and sex, age, school years, self-perceived health, family income, and tension in relationships variables in the models. Finally, we used a backward elimination modeling technique to retain only statistically significant risk factors for injury in the final model; we reported odds ratios with 95% confidence intervals.

In the analysis, the referent group was generally the group with the lowest percentage of injuries. However, because only 10 farmers were 60 years or older, the 15- to 19-year-old group was selected as the referent for the age variable in the analysis.

## Results

A study sample of 1500 farmers was selected. Face-to-face interviews were conducted with 1358 farmers, yielding an overall response rate of 90.5%. The reasons for nonparticipation included working temporarily in another place, being absent from the village when the survey was done, and refusing to participate.

In China, the average length of school education among farmers in rural areas is 8 to 9 years. In this study, most farmers (80.0%) had 1 to 9 years of school education, with self-perceived fair to good health (93.0%). Seventy-five percent of the farmers were in a household with an annual income per family member

TABLE 1—Frequency and Percentage of Agricultural Injuries, by Selected Characteristics, in Chinese Farmers (N = 1358) in Hubei, China, 1995–1997

| | n | No. Injured | Percentage Injured | $P^a$ |
|---|---|---|---|---|
| Sex | | | | |
| Male | 755 | 269 | 35.6 | .282 |
| Female | 603 | 198 | 32.8 | |
| Age, y | | | | |
| 15–19 | 93 | 27 | 29.0 | .157 |
| 20–29 | 273 | 87 | 31.9 | |
| 30–39 | 414 | 137 | 33.1 | |
| 40–49 | 385 | 152 | 39.5 | |
| 50–59 | 183 | 63 | 34.4 | |
| ≥60 | 10 | 1 | 10.0 | |
| School years | | | | |
| 0 | 189 | 54 | 28.6 | .341 |
| 1–6 | 562 | 228 | 40.6 | |
| 7–9 | 521 | 156 | 29.9 | |
| 10–12 | 86 | 29 | 33.7 | |
| Self-perceived health | | | | |
| Poor | 95 | 48 | 50.5 | .001 |
| Fair/good | 1263 | 419 | 33.2 | |
| Annual income per family member, ¥ | | | | |
| <500 | 104 | 54 | 51.9 | .001 |
| 500–999 | 1019 | 354 | 34.7 | |
| ≥1000 | 227 | 56 | 24.7 | |
| Unknown/refused | 8 | 3 | 37.5 | |
| Had pesticide poisoning | | | | |
| Yes | 184 | 93 | 50.5 | .001 |
| No | 1174 | 374 | 31.9 | |
| No. of pesticide applications per week in growing season | | | | |
| 0 | 386 | 86 | 22.3 | .001 |
| 1 | 745 | 296 | 39.7 | |
| 2–3 | 193 | 54 | 28.0 | |
| ≥4 | 34 | 31 | 91.2 | |
| Took bath after pesticide applications[b] | | | | |
| Yes | 707 | 186 | 26.3 | .001 |
| No | 265 | 195 | 73.6 | |
| Used personal protective equipment when applying pesticides[b] | | | | |
| Yes | 561 | 196 | 34.9 | .001 |
| No | 411 | 185 | 45.0 | |
| Tension in relationships with family | | | | |
| Yes | 27 | 17 | 63.0 | .002 |
| No | 1331 | 450 | 33.8 | |
| Tension in relationships with neighbors | | | | |
| Yes | 32 | 22 | 68.8 | .001 |
| No | 1326 | 445 | 33.6 | |
| Stress in life | | | | |
| Yes | 138 | 107 | 77.5 | .001 |
| No | 1220 | 360 | 29.5 | |

[a] $P$ was based on standard $\chi^2$ test for variables with 2 categories and on the Mantel-Haenszel $\chi^2$ test for trend for variables with 3 or more categories.
[b] For those farmers who had applied pesticides on the farm (n = 972).

of ¥500 to ¥999 (US $60–US $120), and 71.6% of the farmers had applied pesticide during the 2-year study period. The leading farm products in the study areas were rice, cotton, and vegetables.

The frequency and percentage of work-related injuries are summarized in Table 1 according to sex, age, school years, self-perceived health, family income, pesticide applications and poisoning, tension in relationships with family and neighbors, and stress in life. Males and females had almost the same injury rate—approximately 1 in 3 (33.0%)—and those aged 40 to 49 years had the highest injury rate (39.5%). Farmers who had self-perceived poor health status, were in low-income families, had experienced pesticide poisonings, had applied pesticides, had tension in their relationships with neighbors, and thought life was stressful were at a statistically significant elevated risk for injuries. Those farmers who usually used personal protective equipment during pesticide application and those who usually took a bath after pesticide application had significantly lower injury rates. Note that the associations between pesticide exposure and work-related injuries were consistently shown by several variables that measured different aspects of exposure (pesticide poisoning, number of applications per week, use of personal protective equipment during pesticide application, and taking a bath after the application). No consistent relationship between education and injury was observed; farmers with 1 to 6 school years had the highest injury rate, and illiterate farmers had the lowest injury rate in this study.

The characteristics of the reported injuries are summarized in Table 2. The leading causes of agricultural work-related injuries among these Chinese farmers were knives/sickles (31.5%), falls (26.1%), hoes (12.2%), and heavy falling objects (10.3%). Only 3.6% of

**TABLE 2—Characteristics of Agricultural Injuries (N = 467) Among Chinese Farmers in Hubei, China, 1995–1997**

| | n | % |
|---|---|---|
| Primary cause of injury | | |
| Knife/sickle | 147 | 31.5 |
| Falls | 122 | 26.1 |
| Hoe | 57 | 12.2 |
| Heavy falling objects | 48 | 10.3 |
| Hatchet/ax | 20 | 4.3 |
| Buffalo | 17 | 3.6 |
| Hammer | 10 | 2.1 |
| Other | 46 | 9.9 |
| Part of body injured | | |
| Extremities | 320 | 68.5 |
| Multiple body parts | 100 | 21.4 |
| Trunk | 27 | 5.8 |
| Head | 20 | 4.3 |
| Medical cost of injury, ¥ | | |
| <100 | 336 | 71.9 |
| 100–200 | 51 | 10.9 |
| >200 | 37 | 7.9 |
| Unknown/refused | 43 | 9.2 |
| Recovery days | | |
| 1–2 | 80 | 17.1 |
| 2–7 | 239 | 51.2 |
| >7 | 106 | 22.7 |
| Unknown/refused | 42 | 9.0 |

the reported injuries were caused by large animals (i.e., buffalo). The injuries typically occurred to the extremities (68.5%). The majority (82.9%) of those injured said that they had sought medical help that cost less than ¥200 (US $25). One week usually was required for recovery from the injury.

Table 3 reports the unadjusted odds ratios, adjusted odds ratios, and 95% confidence intervals for the selected risk factors. Injuries were more likely to occur in those farmers who were in low-income families (<¥500 vs ≥¥1000: adjusted odds ratio [OR]=2.55, 95% confidence interval [CI]=1.45, 4.50; ¥500–¥999 vs ≥¥1000: adjusted OR=1.92, 95% CI=1.34, 2.74), who had more pesticide applications per week (once vs none: adjusted OR=2.31, 95% CI=1.70, 3.13; 2 or 3 times vs none: adjusted OR=1.36, 95% CI=0.89, 2.09; ≥4 times vs none: adjusted OR=16.8, 95% CI=4.70, 59.70), who had tension in relationships with neighbors (adjusted OR=3.67, 95% CI=1.52, 8.89), and who thought life was stressful (adjusted OR=6.10, 95% CI=3.91, 9.53). Those farmers who usually used personal protective equipment during pesticide application (adjusted OR=0.80, 95% CI=0.60, 1.07) and those who usually took a bath after pesticide application (adjusted OR=0.16, 95% CI=0.11, 0.22) were less likely to have agricultural work-related injuries. Although self-perceived poor health status (univariate OR=2.06, 95% CI=1.35, 3.13) and tension in relationships with family members (univariate OR=3.33, 95% CI=1.51, 7.33) were statistically significant risk factors for injury in the univariate analysis, they became nonsignificant risk factors (adjusted OR=1.30, 95% CI=0.79, 2.16; adjusted OR=1.79, 95% CI=0.66, 4.82, respectively) when adjusted for other variables. No consistent associations between age, sex, school years, and injury were found in both univariate and multivariate analysis.

The results from the backward-selection modeling procedure are reported in Table 4. School year, family income level, number of pesticide applications per week, use of personal protective equipment during pesticide application, taking a bath after pesticide application, tension in relationships with neighbors, and stress in life were retained in the final model. Model A indicated that applications of pesticides once and more than 3 times per week were statistically significant factors for injuries. To make results more interpretable, the variable specified for applying pesticides 2 to 3 times per week, which was marginally significant ($P$=.123), was forced into the final model. Models B and C indicated that those farmers who usually used personal protective equipment during pesticide application (OR=0.78, 95% CI=0.58, 1.04) and those who usually took a bath after pesticide application (OR=0.17, 95% CI=0.12, 0.24) were significantly less likely to have agricultural work-related injuries after control for other confounding variables.

## *Discussion*

In the United States, studies have consistently reported that the leading causes of agricultural injuries are machinery and other equipment, falls, and livestock.[6,7,9–14] In China, farming activities are still performed manually on most farms, so it is not surprising that the leading external cause of injuries in our study was hand tools. This finding is consistent with results reported by a community-based study of injury in northwest Ethiopia,[31] which found that the most common injuries were caused by cutting and piercing objects.

The relationship between education (school years) and work-related injuries was inconsistent. In our study, farmers with 1 to 6 school years of education were at a statistically significant higher risk for injury than others. Gadalla[20] found higher agricultural injury rates among the least educated than among those with a high school education but found the highest rates among high school graduates. Other researchers have reported increased rates of injury with more years of education.[12,13,17,31] With data collected from Ohio farmers, Crawford and colleagues[12] found that college graduates were at higher risk for injury compared with all others. Because farming activities are vastly different among various conditions, a mere comparison by years of education may not provide a clear-cut trend.

Like farmers in the United States, Chinese farmers tend to be poor.[32] The financial pressure faced by many farmers impedes the adoption of health and safety behaviors, as financial survival becomes the major concern of the family. Poverty has been shown to be associated with inadequate insurance and poor health care, as well as with other injury risk factors.[8,33–36] Our data indicate that Chinese farmers with annual incomes per family member of less than ¥500 (US $60) or ¥500 to ¥999 (US $60–US $120) had significantly higher risk of injury compared with those with incomes of more than ¥1000 (US $120).

Farming is a very stressful occupation. The combination of urgency, stress, and fatigue plays a role in many farm injuries.[8] The most common stressors include the death of a family member, outbreaks of diseases, uncontrolled events such as slowdowns caused by bad weather, loss of work time caused by prolonged illness, low family income, debts, and production losses.[37] Elements other than specific events or conditions also contribute to stress.[8]

Unfortunately, the relation between life stress and injuries has received little research attention in the field of farm safety. Johnston[21] reviewed 20 studies that provided a quantitative measure of stress and occupational injury and a quantitative assessment of the relation between these 2 factors ($P$ for all studies<.05). Twelve of the 17 studies with quantitative measures had odds ratios greater than 1.0, indicating increased risk of injuries due to stress.

**TABLE 3—Odds Ratios (ORs) and 95% Confidence Intervals (CIs) for Selected Risk Factors Associated With Agricultural Injuries Among Chinese Farmers (N = 1358) in Hubei, China, 1995–1997**

| | Unadjusted OR (95% CI) | Adjusted OR (95% CI) |
|---|---|---|
| Sex | | |
| Male | 1.13 (0.90, 1.42) | 1.00 (0.77, 1.29) |
| Female | 1.00 | 1.00 |
| Age, y | | |
| 15–19 | 1.00 | 1.00 |
| 20–29 | 1.14 (0.68, 1.91) | 1.10 (0.63, 1.91) |
| 30–39 | 1.21 (0.74, 1.98) | 1.01 (0.59, 1.73) |
| 40–49 | 1.60 (0.98, 2.61) | 1.20 (0.69, 2.09) |
| 50–59 | 1.28 (0.75, 2.21) | 1.07 (0.57, 2.00) |
| ≥60 | 0.27 (0.03, 2.25) | 0.25 (0.03, 2.43) |
| School years | | |
| 0 | 0.79 (0.46, 1.36) | 0.64 (0.34, 1.21) |
| 1–6 | 1.34 (0.83, 2.16) | 1.03 (0.61, 1.73) |
| 7–9 | 0.84 (0.52, 1.36) | 0.79 (0.48, 1.33) |
| 10–12 | 1.00 | 1.00 |
| Self-perceived health | | |
| Poor | 2.06 (1.35, 3.13) | 1.30 (0.79, 2.16) |
| Fair/good | 1.00 | 1.00 |
| Annual income per family member, ¥ | | |
| <500 | 3.30 (2.02, 5.38) | 2.55 (1.45, 4.50) |
| 500–999 | 1.63 (1.17, 2.26) | 1.92 (1.34, 2.74) |
| ≥1000 | 1.00 | 1.00 |
| No. of pesticide applications per week | | |
| 0 | 1.00 | 1.00 |
| 1 | 2.30 (1.74, 3.05) | 2.31 (1.70, 3.13) |
| 2–3 | 1.36 (0.91, 2.01) | 1.36 (0.89, 2.09) |
| ≥4 | 36.05 (10.76, 120.77) | 16.75 (4.70, 59.70) |
| Took bath after pesticide applications[a] | | |
| Yes | 0.13 (0.09, 0.78) | 0.16 (0.11, 0.22) |
| No | 1.00 | 1.00 |
| Used personal protective equipment when applying pesticides[a] | | |
| Yes | 0.66 (0.51, 0.85) | 0.80 (0.60, 1.07) |
| No | 1.00 | 1.00 |
| Tensions in relationships with family | | |
| Yes | 3.33 (1.51, 7.33) | 1.79 (0.66, 4.82) |
| No | 1.00 | 1.00 |
| Tensions in relationships with neighbors | | |
| Yes | 4.36 (2.05, 9.28) | 3.67 (1.52, 8.89) |
| No | 1.00 | 1.00 |
| Stress in life | | |
| Yes | 8.25 (5.43, 12.3) | 6.10 (3.91, 9.53) |
| No | 1.00 | 1.00 |

[a]For those farmers who had applied pesticides on the farm (n = 972).

Levenson et al.[38] investigated life change events that people had experienced during the years before and after their injuries. For both males and females, life events and associated stress had increased before their injuries. Our finding that tension in relationships with neighbors and stress in life were significantly associated with work-related injuries agrees with findings in other studies.[8,21,38]

A salient result from this study was that pesticide exposure was strongly associated with work-related injuries. This finding was consistent with results reported by other researchers.[9,10,12,16] Zhou and Roseman[9] reported that farm chemical use was associated with severity of reported injuries among a population-based sample of farm operators in Alabama; however, the specific farm chemicals used were not described. Increased risks of injury among Colorado farmworkers exposed to organophosphate and carbamate insecticides were reported by Stallones et al.[10] By investigating a small number of farmers who had been exposed to organophosphates, which are widely used in sheep dip, researchers at the Queen's Medical Center in Nottingham, England, postulated that widespread use of organophosphates may be contributing to the rising rate of bone fractures in the Western world.[16]

In a study employing a well-designed chronic neurologic symptoms assessment system developed by the World Health Organization, Crawford et al. found a very strong relationship between the neurotoxicity symptom score and injury risk among injured farmers.[12] The relationship persisted after adjustment for the effects of confounding variables. The main concern about pesticide exposure and neurotoxic effects involves the organophosphate pesticides, because acute high-dose or chronic low-dose exposure may result in either delayed polyneuropathy, including peripheral nerve degeneration, or neurobehavioral effects such as difficulty concentrating, confusion, and drowsiness.[12] Reduced hand–eye coordination among those working with pesticides increases the risk of injury.[39] Individuals with a history of occupationally related organophosphate poisoning showed abnormalities on a wide range of neuropsychologic variables, including visuomotor, attention, and language function.[40] Persistent abnormalities in affect, particularly anxiety, also were found.

In an epidemiologic study conducted by Rosenstock et al.[41] in Nicaragua, 36 agricultural workers who had been admitted to a hospital for organophosphate poisoning an average

**TABLE 4—Results of Final Multivariate Logistic Regression Analysis of Agricultural Work Injuries Among Chinese Farmers in Hubei, China, 1995–1997**

| | OR (95% CI) | | |
|---|---|---|---|
| | Model A (N = 1358) | Model B (N = 972)[a] | Model C (N = 972)[a] |
| School years | | | |
| 1–6 | 1.35 (1.05, 1.73) | 1.36 (1.01, 1.85) | 1.51 (1.14, 2.01) |
| Other | 1.00 | 1.00 | 1.00 |
| Annual income per family member, ¥ | | | |
| <500 | 2.80 (1.63, 4.83) | 2.73 (1.32, 5.65) | 3.22 (1.64, 6.32) |
| 500–999 | 1.94 (1.36, 2.77) | 1.82 (1.21, 2.72) | 1.60 (1.08, 2.38) |
| ≥1000 | 1.00 | 1.00 | 1.00 |
| No. of pesticide applications per week | | | |
| 0 | 1.00 | ... | ... |
| 1 | 2.34 (1.74, 3.15) | ... | ... |
| 2–3 | 1.38 (0.92, 2.09) | ... | ... |
| ≥4 | 18.53 (5.21, 65.16) | ... | ... |
| Took bath after pesticide applications[a] | | | |
| Yes | ... | 0.17 (0.12, 0.24) | ... |
| No | ... | 1.00 | ... |
| Used personal protective equipment when applying pesticides[a] | | | |
| Yes | ... | ... | 0.78 (0.58, 1.04) |
| No | ... | ... | 1.00 |
| Tensions in relationship with neighbors | | | |
| Yes | 4.08 (1.80, 9.23) | 3.20 (1.01, 10.19) | 4.58 (1.58, 13.29) |
| No | 1.00 | 1.00 | 1.00 |
| Stress in life | | | |
| Yes | 6.28 (4.05, 9.75) | 6.64 (3.86, 11.41) | 8.71 (5.23, 14.51) |
| No | 1.00 | 1.00 | 1.00 |

*Note.* OR = odds ratio; 95% CI = 95% confidence interval.
[a]For those farmers who had applied pesticides on the farm (n = 972).

of 2 years after the episode of acute intoxication showed a persistent decline in neuropsychologic functioning.

In China, the annual reported cases of acute pesticide poisoning reached about 50000 in 1995, although the statistics are not always complete.[28] Among the total cases reported during 1992 through 1994, acute organophosphate poisoning accounted for 78.8%. More than 1500 cases of carbofuran poisoning and some other cases of poisoning by carbamates, such as carbaryl and aldicarb, also have been reported in the Chinese medical literature.[42] Chronic exposure to those pesticides may be severe, given that most Chinese farmers still use simple manual equipment to apply pesticides and that 42.3% of the farmers in this study did not use personal protective equipment during the pesticide applications.

Unfortunately, no study has been conducted in China to investigate the relationships between pesticide exposure and work-related injuries among farmers. To our knowledge, our study was the first in China to find a strong association between pesticide exposure and work-related injuries. The overall evidence suggests that the risk of work-related injury may increase after high-level exposures to pesticides. However, one limitation in our analysis was that we were unable to evaluate other potential confounding variables, such as type of farming, hours worked, type of pesticides applied, and methods of pesticide application, because information on those variables was not available in the study. Results reported here are considered preliminary findings for injuries among Chinese farmers; this area of research warrants further investigation.

This study had some limitations. In contrast to the 12-month study period used in many studies,[10–14] this study collected data on the most recent injury occurring in the previous 24 months. Studies suggest that the longer the time frame from which the injuries are reported, the higher the possibility of recall bias,[11] leading to an underestimation of the injury rate. However, studies also suggest that recall of injuries requiring medical attention would be less likely to be subject to underreporting.[11] In this study, 82.9% of the injured farmers sought medical treatment for their injuries. Although the selection of the most recent injury to be investigated in this study also might be controversial, this problem is inherent in all studies of frequent and recurrent health problems.[43]

This investigation was a cross-sectional study in which all information about the injuries and the possible risk factors was collected at the same time. Therefore, it is difficult to infer causal relationships between injuries and some of the risk factors, such as self-perceived health and stress in life. The stress could precede or be a result of the injury. A longitudinal study could better assess cause and effect.

Recently, epidemiologists have become increasingly concerned about using available statistical packages to analyze complex survey research data without actually considering the study design. Confronted by the historic lack of available software to appropriately account for the survey design, researchers have often simply ignored the complexities of a survey and analyzed the data as they would for a simple random sample. Although modern programs such as SUDAAN (Research Triangle Institute, Research Triangle Park, NC) and Stata (Stata Corp, College Station, Tex) provide new tools for performing design-based analyses, and our data collection involved a complex study design, our logistic regression analyses were based on assumptions that the data had resulted from a simple random sample. We could not incorporate design features into our data analysis as a result of the lack of essential information about individual counties. However, comparison studies conducted by several research groups found that logistic regression coefficients and their associated standard errors do not differ greatly between the two analytic strategies.[44–46] Although this is reassuring, the potential for differences and the availability of survey analysis software are incentives for the use of design-based techniques in analyzing data from complex sample surveys in future studies.

Even with these limitations, our results suggest that injuries that occur among Chinese farmers may have unique patterns and potential risk factors. Unfortunately, this area has been neglected as a public health problem and as an issue in occupational safety and health in China.[28] As China is changing rapidly toward a newly industrialized country, China's occupational health program should evaluate injuries from public health perspectives to identify national occupational safety and injury research needs and priorities, as other developed and developing countries have done.[2,47,48] In the interim, public health workers should use currently available information as a starting point for action rather than wait for improved evidence to emerge or spend scarce funds on gathering and analyzing sophisticated data.[48] Most important, however, injury control should draw the attention of policymakers and gain support from government, research institutions, local authorities, and the communities. □

## Contributors

H. Xiang, Z. Wang, and L. Stallones conceived and designed the study. H. Xiang and Z. Wang analyzed the data, interpreted the results, and wrote the paper. L. Stallones and T.J. Keefe contributed to the development of analysis strategies, assisted with the writing of the first draft, and helped in the revision of the paper. X. Huang and X. Fu assisted with the study design and collected data with Z. Wang. All authors approved the final version of the paper.

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