ELSEVIER

A Correction Factor for Estimating Statewide Agricultural Injuries from Ambulance Reports

ERIKA E. SCOTT, MS, GIULIA EARLE-RICHARDSON, PHD, NICOLE KRUPA, BS, AND PAUL JENKINS, PHD

PURPOSE: Agriculture ranks as one of the most hazardous industries in the nation. Agricultural injury surveillance is critical to identifying and reducing major injury hazards. Currently, there is no comprehensive system of identifying and characterizing fatal and serious non-fatal agricultural injuries. Researchers sought to calculate a multiplier for estimating the number of agricultural injury cases based on the number of times the farm box indicator was checked on the ambulance report.
METHODS: Farm injuries from 2007 that used ambulance transport were ascertained for 10 New York counties using two methods: (1) ambulance reports including hand-entered free text; and (2) community surveillance. The resulting multiplier that was developed from contrasting these two methods was then applied to the statewide Emergency Medical Services database to estimate the total number of agricultural injuries for New York state.
RESULTS: There were 25,735 unique ambulance runs due to injuries in the 10 counties in 2007. Among these, the farm box was checked a total of 90 times. Of these 90, 63 (70%) were determined to be agricultural. Among injury runs where the farm box was not checked, an additional 59 cases were identified from the free text. Among these 122 cases (63 + 59), four were duplicates. Twenty-four additional unique cases were identified from the community surveillance for a total of 142. This yielded a multiplier of 142/90 = 1.578 for estimating all agricultural injuries from the farm box indicator. Sensitivity and specificity of the ambulance report method were 53.4% and 99.9%, respectively.
CONCLUSIONS: This method provides a cost-effective way to estimate the total number of agricultural injuries for the state. However, it would not eliminate the more labor intensive methods that are required to identify of the actual individual case records. Incorporating an independent source of case ascertainment (community surveillance) increased the multiplier by 17%.
Ann Epidemiol 2011;21:767–772.

KEY WORDS: Agricultural Injury, Surveillance, Ambulance Report.

INTRODUCTION

Agriculture is one of the most hazardous occupations in the nation, with a fatality rate 10 times the all-occupation rate; nonfatal injury rates have been shown to be elevated as well (1). Among fatal injuries, tractor roll-overs, machinery entanglements, and animal incidents have been identified as leading sources (2–4). Children, older farmers, and those with impaired hearing have been found to be at particularly high risk (5–8). However, less is known about serious nonfatal injury in agriculture. In recent years, national surveys have shown tractors to be leading injury sources (2, 9). However, detailed state level and descriptive statistics are not available.

At the Northeast Center for Agricultural Health, researchers are working to establish a state-wide fatal and nonfatal injury surveillance system for agriculture. The aim is to use this information in prevention planning and program evaluation. Researchers have reviewed farm injury cases among ten agricultural counties in New York State from a number of different data sources (10).

One data source in New York that has not been considered for this purpose is the ambulance prehospital care report ("ambulance report"). In New York and many other states, leaders in emergency medical service bureaus have begun to aggregate the reports for research and quality control purposes. In 2003, the National Association of State Emergency Medical Service Officials (NASEMSO) created a memorandum of understanding recognizing the need for the National Emergency Medical Service (EMS) Information System to provide annual data sets in an electronic form, using a consistent data format (11). Thus, ambulance reports are becoming a viable source of existing medical data, similar to death certificates or hospital discharge records.

An ambulance report is generated every time an ambulance is called to an injury event. This data source includes a check box indicating "farm" as the event location. In combination with variables indicating an injury event,

From the New York Center for Agricultural Medicine and Health/Northeast Center for Agricultural and Occupational Health, Bassett Healthcare Network, One Atwell Road, Cooperstown, NY.
Address correspondence to: Erika E. Scott, MS, NYCAMH, NEC, One Atwell Rd, Cooperstown, NY 13326. Tel.: +1-607-547-6023; Fax: +1-607-547-6087. E-mail: erika.scott@bassett.org.
Received March 19, 2011. Accepted July 16, 2011.

360 Park Avenue South, New York, NY 10010
1047-2797/$ - see front matter
doi:10.1016/j.annepidem.2011.07.005

AEP Vol. 21, No. 10
October 2011: 767–772

Selected Abbreviations and Acronyms

EMS = emergency medical services
NEC = Northeast Center for Agricultural Health
NYCAMH = New York Center for Agricultural Medicine and Health

this check box makes identifying farm injuries possible. Additionally, the fact that the individual completing the report is present at the scene of the injury makes it more likely that relevant accident details (e.g., source or mechanism of injury) would be recorded (over what would be recorded later at the hospital). For all of these reasons, it is believed that ambulance reports could be a particularly useful source of surveillance data for agricultural injury.

A study by Forst and Erskine (12) was the first to examine the use of ambulance reports for agricultural injury surveillance. Researchers obtained an electronic data set of all injury-related ambulance runs for a 3-year period for the state of Ohio and extracted all records that indicated "farm" ($n = 1714$) as the run location. The leading causes of injury among this sample were falls (32%), followed by riding animals (14%) and off-road vehicles (13%).

Despite these uses, researchers also found that ambulance data had several significant limitations. First, not all cases identified with the "farm" and "injury" designation would be considered farm-related. One example would be an injury due to a fall within the farmstead home, inappropriately marked as farm, in lieu of the correct "residence." These cases cannot be excluded without actually inspecting the free text. A second limitation relates to insufficient detail being provided in the electronic record describing the circumstances of the injury event. This makes it difficult to characterize the injury source or mechanism of injury. This limits both the ability to confirm the event as a farm injury, and the utility of cases to better the understanding of root injury causes.

The fact that all 50 states have signed the memorandum of understanding with the National EMS Information System, means that electronic EMS data sets are soon likely to be available across the United States. Because it will be a relatively simple and fast process (not requiring identifiers), it is likely that researchers would use the "farm check box" to estimate statewide nonfatal farm injury counts. Before this practice becomes widespread, it is important to have a better understanding of the completeness of ascertainment it provides, and what adjustments might be needed.

This Northeast Center for Agricultural Health study sought to calculate a multiplier that accounts for the extent of under- or over-reporting that may occur when using the farm check box method (as was used in the Ohio study). This was done by obtaining hard copies of all ambulance reports (indicating injury) in 10 highly agricultural New York counties, and confirming or refuting the "farm injury" designation using the free-text description of the incident (detail only available on the hard copies). Further, researchers established a farm accident reporting system in the 10 study counties, whereby county officials reported all farm injury cases on a monthly basis, and indicated whether emergency medical services were involved. These data were used to identify additional cases that may have been missed entirely by the ambulance report system (using either the farm check box or free-text review method).

METHODS

Selection of the 10 Study Counties

Ten counties were selected for review of ambulance report free text. These were selected on the basis of having the largest number of farms, largest agricultural population size, greatest number of farm fatalities over the previous 5-year period, and the greatest number of state-reported EMS "farm" location ambulance runs in 2001. Together these 10 counties account for 11,560 (31.8%) of the state's 36,352 farms, and 27% of the state's agricultural workforce (hired farm labor and operators) (13). As shown in Figure 1, the counties are evenly dispersed across the state.

Initial Selection of Ambulance Reports for Review: Definition of an Injury

Researchers received de-identified paper copies of all ambulance reports for 2007 for the 10 study counties from the state's data management facility. Before these paper ambulance reports were reviewed for injury status, all reports pertaining to health care facilities, industrial accidents, or recreational accidents were removed from consideration by a research assistant. The research assistant also removed reports that did not pertained to an injury using the

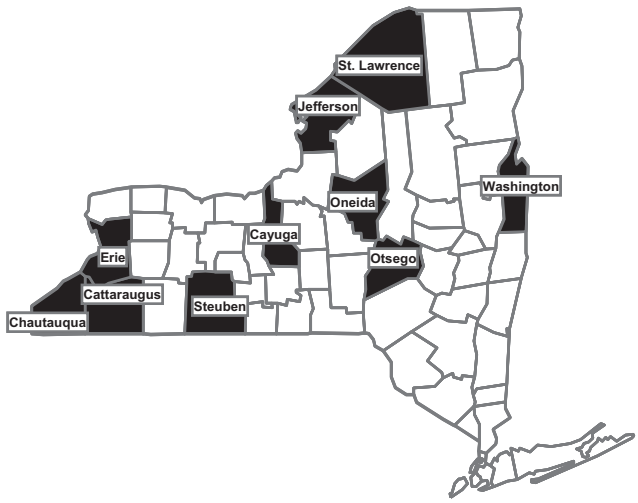

FIGURE 1. Study counties.

"mechanism of injury" and "presenting problems" fields. For mechanism of injury if any field was checked the report was deemed to be an injury. Table 1 shows the list of entries that would qualify for presenting problems.

Determination of a Farm Injury from Ambulance Report Text Fields

Farm injury was defined as any event resulting in the transfer of energy: (1) from a farm source (e.g., tractor, farm animal); (2) while in a farm location; or (3) while doing a farm-work-related activity, that results in physical injury requiring immediate medical attention. Fatal injuries are further defined as those resulting in death, as a direct result of the injury event. The only exclusion to this definition is an injury occurring while in a farm location from an unambiguously nonfarm source, such as a skateboard, family pet, cook stove, and the like.

Researchers then reviewed the free text sections ("chief complaint," "subjective assessment," "objective physical assessment," and "comments") of the paper forms for key terms indicating: farm locations, farm activities and farm structures, livestock, materials, or machinery. A list of these keywords is available from the authors. If there were a term that was not on the list, but might possibly be farm-related, reviewers were instructed to put the report aside for consideration by the full research team. Any paper form containing any of these key words was entered into a Microsoft Access File.

The records in this Microsoft Access file were then reviewed further by a panel of four (two researchers, a physician with experience in agricultural health, and a former dairy farmer). This panel was charged with determining whether these key words occurred within the context of an actual farm injury. To do this, the panel assessed (1) whether the injury occurred while doing farm work or engaged in a farm activity; (2) whether the injury occurred while on a farm location; or (3) whether the injury occurred on a roadway and involved farm equipment and/or farm animals. Injury events occurring on the farm due to leisure sources (e.g., bicycle, skateboard, family pets) were excluded.

TABLE 1. Injury identification variables from ambulance report

Mechanism of injury	Presenting problem
Motor vehicle accident	Unconscious/unresponsive
Struck by vehicle	Poisoning
Fall	Head injury
Unarmed assault	Spinal injury
Gun shot wound	Fracture/dislocation
Knife	Amputation
Machinery	Major trauma
Other (describe)_____	Trauma penetrating
	Soft tissue injury
	Bleeding/hemorrhage
	Burns
	Environmental heat
	Environmental cold
	Hazardous materials
	Other: _____ (if text consistent with injury)

Community Surveillance

Researchers obtained reports from county health officials of farm injuries occurring in the 10 study counties where emergency response was used to identify cases not identified by ambulance reports. Recruitment of EMS personnel, 911 dispatchers, coroners, medical examiners, and law enforcement officials was conducted between November 2006 and February 2007. Commitment was obtained from a total of 36 sources with a minimum of three contacts in each county.

Research staff placed telephone calls on a monthly basis to each county official. If the official was not reached on the first attempt, four additional calls were made at varying times of the day over a 2-week period. At the end of this 2-week period, an e-mail message was sent to the contact. If the county official did not respond to the e-mail, a mailed letter from the project's principle investigator was sent. For each phone call, the individual was asked to report any farm-related injuries or fatalities in their counties over the past 30 days. For each reported injury, collected information included: date and time of the accident, the number of victims involved, whether it resulted in a fatality or nonfatal injury, gender and age of the victim, and EMS transport details. In addition, information about the injury mechanism, machinery or livestock involved, and location on the farm were recorded. Any other related details were recorded as free text. Researchers did not collect any personally identifying information related to injured persons. Data from each incident is then entered into a Microsoft Access database via a double-entry process.

Thirty-two print and online newspapers that serve the 10 study counties were also scanned for farm injuries using the following keywords: "accident," "tractor," and "farm" to identify any additional cases. The online scanning was carried out by a newspaper clipping service using specialized word recognition software. Whenever the software detected one of these key words the full article was sent to a New York Center for Agricultural Medicine and Health (NYCAMH) research assistant for visual confirmation. For each county, the study coordinator and biostatisticians established duplicate reports based on date and time of the incident, age and gender of the victim, and details about the event. For duplicates, the data was combined into a single record.

Coding of Injuries

To the extent possible, all records in the final electronic file were coded as to source of injury (e.g., tractor, cow),

AEP Vol. 21, No. 10
October 2011: 767–772

mechanism of injury (e.g., overturn, kick), and presenting problem (e.g., fracture, blunt trauma). In addition, a variable that combined both the source and mechanism of injury was created. Coding schemes followed the 2009 National Occupational Research Agenda (NORA) agriculture, forestry, and fishing typology (14, 15). Two researchers coded independently, and where discrepancies occurred, the case was referred to a panel (physician, farmer, and 3rd researcher) for final determination.

Data Analysis

Estimation of Sensitivity and Specificity of the Farm Box Location in Identifying True Farm Injuries. The ambulance report has the following location terms: residence, health, farm, industrial, other work, recreational, road, other (with a space to describe). All reports that had the farm location indicated were cross referenced against the determination of a true farm injury that had been made using the free text. Sensitivity was defined as the proportion of true farm injuries for which the farm box was checked. Specificity was defined as the proportion of all reports that were not true farm injuries where the farm box was not checked.

Estimation of the Multiplier to be Applied to the Farm Box Location to Estimate Total Farm Injuries. The final multiplier was defined as:

$$\frac{\text{Total Farm Injuries from Surveillance and Ambulance Reports}}{\text{Total Number of Farm Boxes Checked}}.$$

To estimate intercounty variability for the multiplier, it was calculated separately for each county and the standard deviation was obtained. The distributions of categorical outcome were compared using χ^2, or Fisher's exact test, as necessary.

The research protocol was approved by the Bassett Medical Center Institutional Review Board.

RESULTS

Using the criteria described above for the definition of an injury, of the total 110,448 ambulance runs in the 10 counties, 25,735 (23.3%) were determined to be injuries and therefore qualified for review to ascertain farm status. Among these 25,735, 90 were found to have the farm box checked. Of these 90, text review confirmed that 63 were true farm cases. Among the remaining 25,645 reports for which the farm box was not checked, text review confirmed an additional 59 true farm cases. Among this total of 122 true cases, four were found to be duplicates and removed.

Fisher's exact test indicated no significant difference between the distribution of the combined injury source and mechanism variable between true cases that had the farm box checked versus those that did not ($p = 0.2386$). From these data, the sensitivity of the farm box method can be estimated as the number of true farm cases with farm box checked (63) divided by the total number of true farm cases (118) that yields an estimate of 53.4%. Specificity is estimated as the number of nonfarm cases without the farm box checked (25,586) divided by the total number of nonfarm cases (25,613) that yields 99.9%.

Thirty-one cases requiring ambulance transport were identified through community surveillance. Of these, seven were found to be duplicates of incidents identified by the ambulance forms. Thus, the total number of unique injuries identified from the two methods combined was $118 + 24 = 142$. Thus, this additional surveillance method increased the overall number of injuries identified by $24/118 = 20.3\%$.

As noted above, it was found that the farm box was checked a total of 90 times in this 10-county region where a total of 142 agricultural injuries were documented. Thus, the multiplier to estimate total agricultural injuries from the farm check box is estimated to be $142/90 = 1.58$. To estimate the intercounty variability of this measure it was calculated separately for each of the ten counties, which yielded an unweighted mean of 1.65 and standard error of 0.13 (95% confidence interval [CI]: 1.39–1.91).

For the entire state, excluding the five boroughs of New York City, the farm box was checked on a total of 1530 forms. Thus, the estimated number of true farm injuries for the state is $1530 \times 1.58 = 2417$.

Column 1 of Table 2 shows the distribution of 158 presenting problems reported among the 142 injuries found by the study. For purposes of comparison, column 2 shows the analogous distribution that would have been obtained from simply using the 1530 cases from the entire state for which the farm box was checked. Because each subject may contribute more than one presenting problem, χ^2 analysis was not carried out due to the violation of the assumption of independence.

Table 3 shows similar data for the mechanism of injury. Because each incident may report only a single mechanism, this table also includes projected numbers. Column 1 contains the actual distribution observed among the 142 reports. Column 2, which shows the projected total for the state, is derived in two steps. First, the 1530 state forms for which the farm box was checked was multiplied by 1.58 to obtain the projected statewide total of 2417 injuries. Second, the

TABLE 2. Distribution of presenting problems*

Presenting problem	Percent (%) present in 10-county study region (n = 142)	Percent (%) present in state-wide electronic data set (n = 1530)
Unconscious/unresponsive	2 (1.3)	25 (1.6)
Head injury	21 (13.3)	110 (7.1)
Spinal injury	8 (5.1)	68 (4.4)
Fracture/dislocation	27 (17.1)	147 (9.6)
Major trauma	5 (3.2)	42 (2.7)
Trauma-blunt	31 (19.6)	144 (9.4)
Soft tissue injury	14 (8.9)	88 (5.8)
Bleeding/hemorrhage	7 (4.4)	57 (3.7)
Other	42 (27.2)	801 (52.4)

*Does not add up to 100% because more than one (or none) presenting problems may be chosen per case.

proportions for each mechanism observed among the 142 reports were applied to this total count of 2417. The third column shows the observed distribution of mechanism for the 1530 reports for which the farm box was checked. Chi-square ($\chi^2 = 415.3, p < 0.001$) showed that these two distributions differed significantly.

Table 4 shows the estimated distribution of agricultural injury source for the state. Because this injury source variable can only be derived from examination of text strings in a report, it is not possible to contrast it with the distribution of the 1530 reports for which the farm box is checked.

Applying this multiplier of 1.58 to the number of times the farm box is checked at the county level permits a county-level projection for the number of agricultural injuries.

DISCUSSION

These data show clearly that using the ambulance report farm box to identify agricultural injuries will result in underestimation of the total number of cases as well as errors in the assignment of both the mechanism of injury and presenting problem. Text review revealed that only 70% of reports with the farm box checked were in fact true farm cases. In addition, 59 of the final total of 118 true farm cases that were identified (50%) did not have the farm box checked. These two facts clearly preclude using the farm box alone as a source of agricultural injury surveillance.

TABLE 4. Estimated distribution of agricultural injury sources

Source of injury	10-County study region data (n = 142)	%	State-wide projected totals (using multiplier) (n = 2417)
Tractor	26	18.3	443
Farmstead machinery	2	1.4	34
Nonpowered cart, wagon	5	3.5	85
Livestock (cow/goat/bull)	14	9.9	238
Horse	43	30.3	732
Trees/crops	15	10.6	255
Hand tool	2	1.4	34
Building/structure/surface	5	3.5	85
Truck/auto	4	2.8	68
ATV/MUV	5	3.5	85
Other	15	10.6	255
Unknown	6	4.2	102
Totals	142	100.0	2417

ATV = all terrain vehicle; MUV = multi use vehicle.

Although the multiplier that was derived can be used to estimate the total number of agricultural injuries, it could not be used to isolate a data set for analysis without the prohibitively expensive free text examination. Without this labor intensive process only 50% of the 118 true farm cases would have been identified and the 27 false positive cases could not have been eliminated. It should also be noted that a significant component of the multiplier was due to the community surveillance, which contributed an additional 24 unique cases. Thus, an individual record level file could not have been obtained without both the free text review and the community surveillance. Such a labor intensive system is not feasible as an on-going annual process.

The extent to which this multiplier may remain stable over time is not presently known. The 5-year study that is currently under way at the Northeast Center for Agricultural Health, however, will shed some light on short term (5-year) variability. If this multiplier proves to be relatively

TABLE 3. Distribution of mechanism of injury

Mechanism of injury	10-County study region data (%) (n = 148)	State-wide projected totals (using multiplier) (%) (n = 2417)	State-wide totals (without multiplier) (%) (n = 1530)
Motor vehicle accident	12 (8.5)	204 (8.5)	64 (4.2)
Struck by vehicle	2 (1.4)	34 (1.4)	34 (2.2)
Fall	40 (28.2)	681 (28.2)	179 (11.7)
Unarmed assault	0 (0.0)	0 (0.0)	26 (1.7)
Gun shot wound	0 (0.0)	0 (0.0)	8 (0.5)
Knife	1 (0.7)	17 (0.7)	14 (0.9)
Machinery	15 (10.6)	255 (10.6)	28 (1.8)
Other (describe) _____	18 (12.7)	306 (12.7)	291 (19.0)
Blank	54 (38.0)	919 (38.0)	886 (57.9)
Total	142 (100)	2417 (100)	1530 (100)

AEP Vol. 21, No. 10
October 2011: 767–772

stable over time, this method could be used as a cost effective way to measure the increase or decrease in agricultural injuries over time in response to safety interventions.

Other electronic sources that may contain information on agricultural injuries do exist. Among these are the hospital inpatient and emergency department discharge data sets, and also death certificate databases. It was noted in the results that one additional source of injury identification (community surveillance) increased the total number of injuries identified by ambulance report alone by 20.3 percent. Each of these additional electronic methods of injury identification may increase the total number of cases detected by a similar amount. Therefore, if future research is able to combine these electronic methods with the ambulance reports, it is possible, and even likely, that the current multiplier of 1.58 will need to be dramatically increased.

Because these other electronic sources are completed both away from and after the injury occurrence, they do not contain nearly as much relevant detail as the ambulance reports. In the same vain, the free text available in the ambulance reports adds detail to the injury scenario (16). However, the identification of an actual data set that contains detail on each accident is still not feasible. The future direction of electronic ambulance reports, as proposed by National Emergency Medical Services Information System (NEMSIS), may make the creation of this data set possible.

Limitations

As shown, the degree of overlap between the community surveillance and ambulance reports was very small, with only seven common incidents. It is therefore possible that other sources of injuries, including hospital inpatient and emergency department data, will detect additional cases that neither of these two methods identified. NYCAMH is currently negotiating to obtain these additional data sets to address this issue. This will be a step forward in the establishment of a gold standard for agricultural injury that is currently not available.

This research is made possible through a grant from the National Institute for Occupational Safety and Health (NIOSH) (U50-OH007542). Special thanks to the New York State Department of Health, Bureau of Emergency Medical Services.

REFERENCES

1. BLS. Bureau of Labor Statistics. CFIO Charts, 2008. Available at: http://www.bls.gov/iif/oshwc/cfoi/cfch0007.pdf. Accessed July 14, 2010.
2. Goldcamp EM. Work-related non-fatal injuries to adults on farms in the U.S., 2001 and 2004. J Agric Saf Health. 2010;16:41–51.
3. Myers JR, Hard DL. Work-related fatalities in the agricultural production and services sectors, 1980-1989. Am J Ind Med. 1995;27:51–63.
4. Murphy DJ, Ambe F. Pennsylvania farm fatalities during 1990-94. National Ag Safety Database. 1998. Available at: http://nasdonline.org/static_content/documents/992/d000975.pdf.
5. Hwang SA, Gomez MI, Stark AD, St John TL, May JJ, Hallman EM. Severe farm injuries among New York farmers. Am J Ind Med. 2001;40:32–41.
6. Lim GW, Belton KL, Pickett W, Schopflocher DP, Voaklander DC. Fatal and non-fatal machine-related injuries suffered by children in Alberta, Canada, 1990-1997. Am J Ind Med. 2004;45:177–185.
7. Amshoff SK, Reed DB. Health, work, and safety of farmers ages 50 and older. Geriatr Nurs. 2005;26:304–308.
8. Hagel LM, Dosman JA, Rennie DC, Ingram MW, Senthilselvan A. Effect of age on hospitalized machine-related farm injuries among the Saskatchewan farm population. J Agric Saf Health. 2004;10:155–162.
9. Myers JR, Layne LA, Marsh SM. Injuries and fatalities to U.S. farmers and farm workers 55 years and older. Am J Ind Med. 2009;52:185–194.
10. Earle-Richardson GB, Jenkins PL, Scott EE, May JJ. Improving agricultural injury surveillance: a comparison of incidence and type of injury event among three data sources. Am J Ind Med. 2011;54:586–596.
11. NEMSIS. National Emergency Medical Services Information System, 2010. Available at: www.nemsis.org. Accessed December 2, 2010.
12. Forst L, Erskine T. Farm Injuries in Ohio, 2003-2006: a report from the emergency medical services prehospital database. J Agric Saf Health. 2009;15:171–183.
13. United States Department of Agriculture. 2007 Census of Agriculture. 2008; Available at: http://www.agcensus.usda.gov/Publications/2007/Full_Report/index.asp. Accessed June 24, 2010.
14. National Institute for Occupational Safety and Health. National Occupational Research Agenda: National Agriculture, Forestry, and Fishing Agenda. 2008. Available at: http://www.cdc.gov/niosh/nora/comment/agendas/AgForFish/pdfs/AgForFishDec2008.pdf. Accessed July 13, 2010.
15. American Society of Agricultural and Biological Engineers. Farm and Agricultural Injury Classification (FAIC) Code. ASAE S575.1 MAR2002 (R2007). Available at: http://bbs.6jc.cn/pdf/usa/ASAE%20S575%5B1%5D.1%20%20March%202002%20Farm%20and%20Agricultural%20Injury%20Classification%20(FAIC)%20Code.pd. Accessed August 10, 2011.
16. Lincoln AE, Sorock GS, Courtney TK, Wellman HM, Smith GS, Amoroso PJ. Using narrative text and coded data to develop hazard scenarios for occupational injury interventions. Injury Prev. 2004;10:249–254.