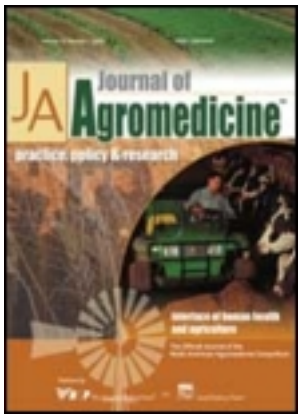

Journal of Agromedicine
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/wagr20

Incidence and Cost of Nonfatal Farm Youth Injury, United States, 2001-2006

Eduard Zaloshnja PhD [a], Ted R. Miller PhD [a] & Barbara C. Lee PhD [b]
[a] Pacific Institute for Research and Evaluation, Calverton, Maryland, USA
[b] National Farm Medicine Center, Marshfield Clinic Research Foundation, Marshfield, Wisconsin, USA

Available online: 04 Jan 2011

To cite this article: Eduard Zaloshnja PhD, Ted R. Miller PhD & Barbara C. Lee PhD (2010): Incidence and Cost of Nonfatal Farm Youth Injury, United States, 2001-2006, Journal of Agromedicine, 16:1, 6-18

To link to this article: http://dx.doi.org/10.1080/1059924X.2011.534714

Journal of Agromedicine, 16:6–18, 2011

ISSN: 1059-924X print/1545-0813 online
DOI: 10.1080/1059924X.2011.534714

Taylor & Francis
Taylor & Francis Group

ORIGINAL RESEARCH

Incidence and Cost of Nonfatal Farm Youth Injury, United States, 2001–2006

Eduard Zaloshnja, PhD
Ted R. Miller, PhD
Barbara C. Lee, PhD

ABSTRACT. The objective of this study was to estimate the annual incidence and cost of nonfatal farm youth injury in the United States for the period 2001–2006. The authors used 2001–2006 Childhood Agricultural Injury Survey data to estimate the annual incidence of farm youth nonfatal injury. To estimate the costs for injuries suffered by youth working/living on the farm, the number of injuries was multiplied by published unit costs by body part, nature of injury, and age group. The annual number of nonfatal injuries to youth (ages 0–19) on farms in 2001–2006 was 26,570. The annual cost of nonfatal farm youth injuries was $1 billion (in 2005 dollars), with 26% of costs related to working on the farm and 47% on beef cattle farms. Around 9.3% of the cost was medical costs, 37.2% work and household productivity loss, and 53.5% quality of life loss.

KEYWORDS. Farm youth, injury costs, injury incidence

INTRODUCTION

Injury is a common and costly childhood affliction, accounting for approximately 15% of medical spending among those aged 1 to 19 years.[1] Indeed, for children and adolescents 5 to 19 years of age, injury rivals the common cold in frequency.[1] Injuries, however, are much more likely than colds to have lasting effects. In 2000, almost 160,000 were permanently disabled as a result of an injury.[2]

Agricultural production—farming—consistently ranks among the industries with the highest rates of work-related injuries in the United States. It also ranks in the highest echelon in injury cost per worker.[3] Family farming is unique in employing large numbers of largely unpaid children and adolescents, often looking on their work as doing

Eduard Zaloshnja and Ted R. Miller are affiliated with Pacific Institute for Research and Evaluation, Calverton, Maryland, USA.

Barbara C. Lee is affiliated with the National Farm Medicine Center, Marshfield Clinic Research Foundation, Marshfield, Wisconsin, USA.

This study was funded by NIOSH grant U54 OH009568.

Address correspondence to: Eduard Zaloshnja, PhD, Research Scientist, Pacific Institute for Research and Evaluation, 11720 Beltsville Drive, Suite 900, Calverton, MD 20705, USA (E-mail: zaloshnja@pire.org).

chores. Family farming is the primary industry where the workplace typically is integrated with the home. Youth, children, and adolescents, who commonly work on farms, are exposed to agricultural production hazards. Although the Fair Labor Standards Act of 1938 (FLSA) and its amendments set standards for child labor in agriculture, it only covers employees whose work involves production of agricultural goods that are part of interstate commerce. In addition, FLSA regulations do not apply to youth working for their parents or guardians on the family's farm or to visiting youth. Household youth account for over 60% of all youth work injuries on farms and visitors for another 15%.[4] Youth who work on farms are often not protected by workplace safety and health regulations from the Occupational Safety and Health Administration (OSHA) because they frequently work for small farming operations that are not inspected by OSHA, or because OSHA regulations do not apply to farm household members and visitors. Moreover, small family farms are exempt from the Workers' Compensation system in most states and thus do not have access to the system's loss prevention/safety programs. Finally, youth on farms have virtually no protection against injuries from nonwork activities that expose them to the same hazards as work activities. For example, a child playing in the field and a child working in the field face the same risks of pesticide poisoning, heat stress, and being run over by farm vehicles.

In 2006 an estimated 1.1 million youth lived on farms, 307,000 additional youth worked as hired farm laborers, and 29.3 million youth visited a farm.[5] During that year, youth less than 20 years of age suffered an estimated 22,900 farm-related injuries. Over 50% (11,700) of these injuries were to youth living on the farm.[4] Approximately 60% of the household youth injuries were to males. Youth between the ages of 10 and 15 years experienced the highest number of farm-related injuries (over 10,000, or around 44%). The most common types of injuries were fractures (27%) and cuts (21%). The body parts most commonly injured were the arm (19%), leg (16%), and hand, wrist, and finger (14%).

Farm injury rates have fluctuated over time. Hendricks and Hendricks[6] compared childhood agricultural injury rates of 1998, 2001, 2004, and 2006. They found that the injury rate for household youth declined from 13.9/1000 in 1998 to 9.8/1000 in 2006. Over four study periods, the number and rate of all injuries declined for male youth; however, the rate and number of injuries increased for female youth in 2001 then declined in the two following periods. Rivara[7] reported a rate of 17.2 injuries per 1000 child farm residents in 1991–1993, 10.7% higher than in 1979–1983. Tractors accounted for 20.9% of all injuries, followed by horses (8.4%), all terrain vehicles and minibikes (8.0%), and farm wagons (7.7%).

Gerberich et al.[8] estimated that in the five-state region of Minnesota, Wisconsin, North Dakota, South Dakota, and Nebraska, farm household youth injury rates for farming and nonfarming sources, respectively, were 16.8 and 69.8 per 1000 persons in 1990. Animals (40%) were the primary sources of injuries related to farming operations; sports/recreation sources (61%) were associated primarily with non-farming related injuries. Of the farming and nonfarming injury cases, 83% and 90%, respectively, required some type of health care; moreover, 17% and 24%, respectively, were restricted from regular activities for 1 month or more. Statistically significant increased injury rate ratios were observed for operating a tractor, working with dairy cattle, and being male.

Quantifying the costs associated with child agricultural injuries is important. Cost estimates reduce different outcomes or injuries—an arm mangled by a rotating shaft, a foot crushed by a cow, a rattlesnake snakebite while mending fence—to a common metric.[1] This makes cost data a useful element in gauging the relative size of various problems, assessing risks, setting research priorities, and selecting interventions that most efficiently reduce the burden of injury. For example, injury costs by diagnosis can inform a decision between spending the safety budget to repair hayloft ladders (estimated to prevent seven broken legs and 23 broken arms) or to retrofit old tractors with rollover protection structures (ROPS) (estimated to prevent two traumatic brain injuries). On a broader scale, comparably measured costs of injury and illness can provide insight into

the relative magnitude of these problems, and may inform resource allocation. Finally, cost data can be used for advocacy purposes, by conveying risk reductions in a way that captures the attention of policy makers, insurers, the media, and the public. Although both risk reduction and cost savings are important, communicating the benefit in monetary terms may provide useful insights for agribusiness leaders and policy makers concerned with cost control.

Only one study has explored the cost of agricultural injury in depth. Leigh et al.[9] estimated that in 1992, agricultural occupational injuries cost an estimated $4.57 billion. Direct medical and administrative costs were estimated at $1.66 billion and indirect costs of lost work at $2.93 billion. A separate estimate for child agricultural injuries was not provided.

This study probes both incidence and costs of nonfatal farm youth injuries. It analyses them from different perspectives: relation to farm and gender, relation to farm and age, type of farm and work status, type of farm and age, injury source and age, and injury event and age. Fatality data are excluded because they lack information about relation to farm, farm type, source, and event.

METHODS

Injury Incidence

We used three waves of Childhood Agricultural Injury Survey (CAIS) data (public use files for 2001, 2004, and 2006) to estimate the annual incidence of farm youth injury. We extracted cases from CAIS files where youth under age 20 were injured on the farm. CAIS collects data on nonfatal childhood injuries on farms that occurred during a calendar year from a random sample of farms across the United States.[10] The CAIS is conducted using a Computer Assisted Telephone Interview (CATI) survey instrument. Randomly selected farming operations across the United States are contacted by eight calling centers during February and March of the following year. The CAIS is conducted in these winter months to increase the response rate of the survey. The average response rate for the three waves was 71%. All agricultural production operations, excluding large swine confinement operations, are included in the study population. For the survey, a farm is defined as any operation of $1000 or more of gross agricultural production within a calendar year, and includes both crop and livestock operations. An injury is defined as any condition that results in 4 hours or more of restricted activity (e.g., person cannot perform work or other normal duties, misses work, misses school), or a condition that requires professional medical treatment.

In the survey, a youth is defined as any person under the age of 20 years. Household youth are defined as all youth who reside on the farm. Hired farm workers are defined as youth who are hired directly by the farm operator (excluding contract laborers) to work on the farm, but are not household members. Visitors are defined as all other youth who are on the farm, but are not household members or hired workers. An agricultural work-related injury is defined as any medically treated or restricted activity injury that occurred while performing work on the farm associated with the farm business, including chores. Nonwork injuries are defined as injuries occurring on the farm that are not due to farm work. The survey excludes injuries to contractors working for the farm operation, or injuries that occur to youth off the farm property. All information provided in the survey is self-reported by the farm operator, spouse, or the injured youth if they are 16 years of age or older so responses to items such as age and the cause of the injury event are subject to the interpretation of the respondent. Although the total number of childhood agricultural lost-time injuries is requested for the calendar year, descriptive information is only requested for the four most recent injury events.

CAIS is based on a stratified random sample of 50,000 farm operations drawn to provide estimates for the study population. The strata for the sampling design are the four Bureau of the Census geographic regions.[11] An equal sample allocation of 12,500 farms is selected in each region. A farm is considered to be a valid member of the sample regardless of whether youth were on the

farm in the year covered by the survey. Our analysis was conducted in SAS 9.2 (http://support.sas.com/documentation/index.html) using its survey procedures that account for sample stratification.

Injury Costs

Medical Costs

To estimate the medical costs for injuries suffered by youth working/living on the farm, we multiplied the number of injuries by published unit medical costs[2,12,13] by hospitalization status, body part, nature of injury, and age group (0–4, 5–14, 15–19). That work estimated incidence-based costs, which represent the present value of the lifetime costs that may result from injuries that occur during a single year. Like this article, it converted all costs (and quality-adjusted life year [QALY]) losses in future years to present value using the 3% discount rate prescribed by the Panel on Cost-Effectiveness in Health and Medicine.[14] We inflated the costs to 2005 dollars using the Consumer Price Index—Medical Care.

Finkelstein et al.[13] and Miller et al.[2] estimated medical costs separately for hospitalized and nonhospitalized cases. They derived estimates of direct costs for hospitalized injuries from the 2000 Healthcare Cost and Utilization Project—Nationwide Inpatient Sample (HCUP-NIS) data supplemented by Medstat's MarketScan database for nonfacility fees, the Uniform Data System for Medical Rehabilitation (UDSMR), the Medical Expenditure Panel Survey (MEPS), and hospital cost-to-charge ratios provided by the Agency for Healthcare Research and Quality (AHRQ). For nonhospitalized injuries, they used the 1999 MEPS data to quantify direct medical costs. MEPS participants with injury-related expenditures but without an inpatient admission were divided into three categories by primary treatment location: 1 = any emergency department utilization; 2 = any outpatient but no office-based or emergency department utilization; and 3 = any office-based utilization but no emergency department utilization. For each diagnosis grouping (classified using the Barell Injury Diagnosis Matrix, http://www.cdc.gov/nchs/data/ice/final_matrix_post_ice.pdf), by primary treatment location, they calculated mean 18-month medical costs by summing costs across all treatment locations of the same type (including prescription drug costs) and dividing by the number of individuals who received treatment in that primary location type.

Even pooling 3 years of CAIS data, the number of nonhospitalized injuries is too small for each treatment location to yield stable/reliable distributions by diagnosis grouping, especially in breakdown tables (e.g., by farm type or for common sources such as tractors or animals). Therefore, the costing of nonhospitalized injuries began by combining costs by diagnosis grouping into averages across treatment settings based on the overall unintentional childhood injury hospitalization rate for the specific diagnosis grouping (from the data base underlying Miller et al.[2] and Finkelstein et al.[13]). We also modified maps we already have developed that map International Classification of Diseases, 9th Edition, Clinical Modification (ICD9-CM) diagnosis codes to American National Standards Institute Z16.2 occupational injury codes, collapsing them into the CAIS body part and nature of injury codes (CAIS map available from the authors). Using the maps, we collapsed our existing unintentional injury costs by age group and detailed ICD9-CM diagnosis into costs by CAIS diagnosis category, weighting the costs with national unintentional injury incidence data by detailed diagnosis and age group. For example, if the CAIS category were hand/finger fracture and ICD9-CM included separate codes for hand fracture and for finger fracture, the CAIS cost would equal

$$(\text{Cost(hand)} \times \text{no. hand} + \text{Cost(finger)} \times \text{no. finger})/(\text{no. hand} + \text{no. finger})$$

where all the values in the equation are for the relevant age group.

The methods described here for merging the medical cost estimates onto the CAIS data were used for the other cost categories as well.

Short-Term Work Loss

The CAIS provides information about the length of time that normal activities are restricted as a result of injury. The time intervals, however, are too broad to be very useful: up to 1 day, 1 week, 2 weeks, 1 month, 3 months, and more than 3 months. Moreover, work days lost by injured youth are not recorded. CAIS only records how many hours per week the injured youth typically worked on the farm at the time of injury (and only if the injury was work related). Except in the summer, farm youth typically work part time. Given this lack of detail in CAIS, we estimated indirectly the number of work days lost by youth due to injury. For that, we used the mean work days lost per unintentional injury by body part and nature of injury for employed injury victims from Finkelstein et al.[13] collapsed into CAIS categories. The percentage of a 40-hour week worked reported in the survey was used as a multiplier to factor down the injured youth's wage work loss. For example, if an injured adolescent worked a maximum of 20 hours per week rather than 40 hours and the average US worker lost 4 days for the same injury, the work loss for the adolescent will be 2 days. For youth injured on the farm while doing chores or conducting recreational activities and who were reported as working on the farm at any time during the calendar year, we assumed the same farm work pattern as for their counterparts who were injured while working. To estimate the value of short-term work loss by the youth, we assumed that the farm operator will hire somebody else to do the work missed by the injured youth. Losses in household productivity were not factored down as they tend to be daily responsibilities; the days lost and cost per day by age group and gender came from Miller et al.[2] Following Miller et al.,[2] we included parental work loss due to youth injury. Work and household productivity losses were inflated to 2005 dollars using the Employment Cost Index (ECI), total compensation for total private employment.

Long-Term Work Loss

The CAIS provides information on whether the injury resulted in permanent disability but its sample is too thin to capture small disability probabilities accurately. It also does not indicate the degree of disability. Miller et al.,[15] Leigh et al.,[3] and Finkelstein et al.[13] developed data by body part and nature of injury derived from a national sample of Workers' Compensation data on the probability the person is totally disabled and the mean percentage of work-related disability for people who are partially permanently disabled. Finkelstein et al.[13] provided some independent validation of these estimates. Given the modest disability information in CAIS, we used these percentages to estimate the lifetime work loss for permanently disabled youth independently of their future occupation. To compute work loss due to permanent disability, we considered permanent total disability and permanent partial disability separately. For permanent total disability, we multiplied the present value of age- and sex-specific lifetime earnings and household production reported in Haddix et al.[16] by the probability of permanent disability for each type of injury. For permanent partial disability, we multiplied the estimate for a permanent total disability by an additional factor from Leigh et al.[3] identifying the percentage of disability. We then summed the results to compute the net long-term work loss associated with permanent disability.

Quality-Adjusted Life Years Lost

The medical and work loss costs associated with child and adolescent injuries do not fully capture the burden of these injuries. Injuries also reduce the quality of life of children and families. Losing a child unnecessarily to injury can cause a lifetime of mental anguish. Children and youth who are permanently disabled by injury may experience lifelong pain, or suffer permanent loss of motor or cognitive functioning. Both monetary costs and quality of life measures should be considered when allocating resources, and both should be incorporated into cost-effectiveness analyses that weigh "net costs" against quality of life improvements.[14] To capture these less quantifiable consequences of child and adolescent injuries, we report quality of life losses, valued in nonmonetary terms as QALYs.

Estimating QALYs is one way to value the good health lost to an individual who suffers a health problem, is disabled, or dies prematurely. A QALY is a measure based on individuals' preferences for states of health that assigns a value of "1" to a year of perfect health and "0" to death.[14] QALY losses are affected by the duration and severity of a health problem. To estimate QALY losses, years of potential life lost to a fatal injury are added to the number of years spent with an injury-related disability times a "weighting factor" that represents the severity of the disability.[15]

We used the present value of the QALYs lost per case by body part and nature of injury from Miller et al.[2,15] to estimate QALY loss for youth injured on farms. Miller et al.[2,15] based QALY loss estimates on physician ratings of the functional losses resulting from injury by diagnosis. Its estimates are routinely used in regulatory analysis by the US Department of Transportation. We provide two sets of quality of life loss estimates, one in QALYs and the second in monetized QALYs. The dollar value per QALY comes from Miller et al.,[2] inflated to 2005 dollars using the ECI.

RESULTS

Table 1 provides estimates of annual incidence and costs of injury to farm youth by relation to farm, age group, and detailed cost categories. The annual number of nonfatal farm youth injuries in 2001–2006 was 26,570. Age groups 10–14 and 15–19 were more prone to nonfatal injury than younger children—their shares of injuries were 36% and 32.4%, respectively (95% confidence intervals: 25.4%–46.6% and 23.8%–41%). They were followed by the 5–9 age group with 23% (95% confidence interval: 18.8%–27.2%) and the 0–4 age group with 9% (95% confidence interval: 5.2%–12.8). As expected, among household youth working and hired youth, the 15–19 age group had the highest share of injuries. Among household youth not working and farm visitors, the 10–14 age group had the highest share of injuries.

Nonfatal farm youth injuries annually cost $1 billion (in 2005 dollars), or $466 million, excluding QALY loss. Around 9.3% of the total cost was comprised of medical costs, 37.2% of work and household productivity loss, and 53.5% of QALY loss. Household youth not working had the highest share of injury costs (54%; 95% confidence interval: 48.2%–59.4%). The overall mean cost was $ 37,744 per case, or $17,526 excluding QALY loss. Importantly, mean costs per injured youth did not differ significantly between any of the groups of youth listed in Table 1 (p values ranged from .12 to .86).

Table 2 indicates that 45.1% occurred to household youth not working (95% confidence interval: 39.6%–50.6%). Hired youth had the smallest share of injuries (5.2%; 95% confidence interval: 1.7%–8.7%). Males experienced more injuries than females. Overall, 58% of injuries occurred to males (95% confidence interval: 54.5%–61.5%). Again mean costs per injury did not differ significantly among groups (p values ranged from .14 to .91).

Table 3 shows that beef cattle farms (31% of all US farms) accounted for 48% of all child agricultural injury costs including 62% of work-related costs and 42% of nonwork costs. Hog farms, however, had the highest rate of youth injuries at work (14.3 per thousand farms; 95% confidence interval: 11.3–17.3) and sheep, goat, wool, and mohair farms had the highest rate of not-at-work injuries (45.4 per thousand farms; 95% confidence interval: 38.5–52.3). The rate of at-work injury in hog farms is not statistically different from rates in dairy and sheep/goat/wool/mohair farms (p values: .38 and .93, respectively). Similarly, the rate of not-at-work injury in sheep, goat, wool, and mohair farms is not statistically different from rates in hog and poultry/egg farms (p values: .06 and .09, respectively). Overall, the rate is 2.4 times higher for not-at-work than for at-work injuries (p value: .001). Not-at-work injury costs represented 71.4% of the total cost of farm youth injury (95% confidence interval: 65.3%–77.5%). At the 95% confidence level, only mean costs per injury for youth working on tobacco and cotton farms were significantly different from other groups (p value: .048).

Table 4 shows that youth 15–19 years old on beef cattle farms had the most injuries

TABLE 1. Annual Incidence and Costs of Nonfatal Farm Youth Injury in 2001–2006 by Relation to Farm and Age Group, Ages 0–19 (2005 Dollars)

Relation to farm and age	Annual incidence	Medical cost*	Short-term child work loss*	Short-term parental work loss*	Short-term child household productivity loss*	Long-term work loss*	Long-term household productivity loss*	Monetized QALY loss*	Total costs net of QALY loss*	Total cost*	Total QALYs lost	Mean cost net of QALY loss	Mean cost
Household youth working	5486	34.0	1.78	4.33	1.04	77.7	18.5	118.2	137.3	255.4	939	25,022	46,566
05–09	609	1.1	0.10	0.44	0.00	4.0	1.0	2.8	6.7	9.5	21	10,925	15,566
10–14	2054	4.7	0.52	1.68	0.31	15.0	3.6	18.7	25.8	44.5	146	12,564	21,680
15–19	2823	28.2	1.16	2.22	0.73	58.6	13.9	96.6	104.8	201.4	772	37,126	71,358
Household youth not working	12,047	39.2	3.90	15.09	1.21	127.7	30.2	323.5	217.4	540.9	2631	18,046	44,901
00–04	1574	6.5	0.00	2.69	0.00	20.9	5.1	57.7	35.3	92.9	470	22,397	59,028
05–09	3405	8.9	0.65	3.73	0.00	36.2	8.6	64.1	58.0	122.1	513	17,037	35,875
10–14	4715	16.9	2.02	6.05	0.83	45.8	10.8	108.6	82.4	191.0	880	17,485	40,510
15–19	2353	7.0	1.24	2.62	0.38	24.8	5.7	93.2	41.7	134.9	768	17,717	57,308
Visitor	7650	17.5	0.00	8.16	0.88	59.5	15.0	90.0	101.1	191.1	711	13,214	24,976
00–04	851	2.0	0.00	0.48	0.00	4.7	1.1	4.1	8.2	12.4	31	9685	14,523
05–09	1969	3.6	0.00	1.67	0.00	13.6	3.3	22.8	22.2	45.0	182	11,276	22,873
10–14	2653	6.7	0.00	3.73	0.55	25.8	6.7	36.9	43.5	80.4	290	16,390	30,293
15–19	2177	5.2	0.00	2.28	0.33	15.5	3.9	26.2	27.2	53.3	208	12,475	24,485
Hired youth	1387	2.3	0.45	0.87	0.10	5.0	1.2	5.5	9.9	15.4	42	7164	11,128
10–14	132	0.4	0.05	0.14	0.02	0.9	0.2	2.1	1.7	3.9	17	13,234	29,488
15–19	1255	1.9	0.40	0.73	0.08	4.1	1.0	3.4	8.2	11.5	25	6525	9195
All 00–04	2425	8.4	0.00	3.16	0.00	25.6	6.3	61.8	43.5	105.3	501	17,937	43,414
All 05–09	5983	13.7	0.75	5.85	0.00	53.8	12.8	89.8	86.9	176.7	715	14,518	29,528
All 10–14	9554	28.6	2.59	11.60	1.71	87.6	21.3	166.3	153.5	319.8	1,333	16,065	33,473
All 15–19	8609	42.2	2.80	7.85	1.51	102.9	24.5	219.3	181.8	401.2	1,773	21,124	46,599
All youth	26,570	93.0	6.13	28.46	3.23	270.0	64.9	537.2	465.7	1002.9	4,322	17,526	37,744

*In millions.

TABLE 2. Annual Incidence and Costs of Nonfatal Farm Youth Injury in 2001–2006 by Relation to Farm and Gender, Ages 0–19 (2005 Dollars)

Relation to farm and gender	Annual incidence	Medical cost*	Short-term work and household productivity loss*	Long-term work and household productivity loss*	Monetized QALY loss*	Total cost*	Total QALYs lost
Household youth working	5486	34.0	7.2	96.1	118.2	255.4	939
Males	3215	6.6	3.9	19.9	21.1	51.6	165
Females	2270	27.4	3.3	76.2	97.1	203.9	774
Household youth not working	12,047	39.2	20.2	158.0	323.5	540.9	2631
Males	6682	22.6	11.1	84.9	192.8	311.4	1574
Females	5365	16.6	9.1	73.1	130.7	229.6	1057
Visitors	7650	17.5	9.0	74.6	90.0	191.1	711
Males	4384	9.1	4.5	37.5	38.1	89.3	297
Females	3266	8.4	4.5	37.1	51.9	101.8	414
Hired youth	1387	2.3	1.4	6.2	5.5	15.4	42
Males	1109	2.1	1.1	5.7	5.0	13.9	39
Females	279	0.3	0.3	0.5	0.5	1.5	3
All males	15,390	40.4	20.6	148.0	257.1	466.1	2075
All females	11,181	52.6	17.2	186.9	280.1	536.8	2248
All youth	26,570	93.0	37.8	334.9	537.2	1002.9	4322

*In millions.

(2542). They were followed by youth 10–14 and 5–9 years old on beef cattle farms (2425 and 2182, respectively). However, 10–14 year olds on sheep, goat, wool, and mohair farmshad the highest injury rate (28.6 per thousand farms). Their rate is statistically different at the 95% confidence level from all other age group and farm type combinations (*p* values ranged from .001 to .047). The beef cattle/15–19 age group combination had by far the highest annual cost ($241 million), of which $30 million was comprised of medical costs.

Table 5 indicates that structures and surfaces were by far the most common source of injury to farm youth in the age groups 0–4, 5–9, and 10–14 years old (999, 2601, and 3373 injuries annually, respectively). For the 15–19 age group, persons, plants, animals, and minerals were the main source of injury (2431 annually), followed by structures and surfaces (1960 injuries annually). The incidence difference between the two sources for this age group is not statistically significant (*p* value: .06). Injuries to 15–19 year olds caused by persons, plants, animals, and minerals had the highest share of the total cost among all the source/age group combinations (20%), followed by injuries caused by structures and surfaces (9.5%). Mean costs per injury do not differ significantly by source/age group or by injury event/age group (*p* values ranged from .11 to .93).

Table 6 indicates that falls were the most common type of injury event in the age groups 0–4, 5–9, and 10–14 years old (1278, 3090, and 3165 injuries annually, respectively). For the 15–19 age group, contacts with objects or equipment were by far the most common injury event (3122 annually). Assault/violent acts to this age group had the highest share of the total cost among all the event/age group combinations (16.5%), followed by falls of 10–14 year olds (12.3%).

DISCUSSION

Nonfatal farm youth injuries cost society at least $1 billion annually during the period 2001–2006 including $463 million in tangible costs and $537 million in quality of life loss. These

TABLE 3. Annual Incidence and Costs of Nonfatal Farm Youth Injury in 2001–2006 by Work Status and Type of Farm, Ages 0–19 (2005 Dollars)

Work status and type of farm	Annual incidence	Rate/1000 Farms**	Medical cost*	Work and household productivity loss*	Monetized QALY loss*	Total cost*	Total QALYs lost	Total cost per farm**
All farms, injured while working	7795	3.6	38.0	117.6	131.2	286.8	1041	132
Grain and oilseed	922	2.7	3.6	24.6	13.4	41.6	99	121
Tobacco and cotton	125	3.5	0.1	0.1	0.1	0.3	1	9
Vegetable and melon	262	7.0	0.3	0.7	0.8	1.7	6	46
Fruit, tree nut, and berry	158	1.6	0.2	0.5	0.3	1.1	2	11
Nursery, greenhouse, and floriculture	166	2.8	0.5	2.2	1.3	4.0	10	68
Other crop	814	1.8	2.4	6.7	5.3	14.4	41	32
Beef cattle	2154	3.1	25.4	63.2	89.7	178.4	722	253
Dairy	725	11.2	1.6	8.5	4.4	14.5	32	223
Hog	457	14.3	0.7	2.0	1.8	4.5	14	141
Sheep, goat, wool, and mohair	796	14.2	1.3	2.7	3.4	7.4	27	133
Equine	814	4.6	1.2	4.4	7.5	13.1	61	75
Poultry and egg	245	4.5	0.3	0.9	1.8	3.0	15	55
Other animal	158	2.6	0.2	1.0	1.4	2.7	12	43
All farms, injury while not working	18,776	8.7	55.0	255.1	406.0	716.1	3281	330
Grain and oilseed	1899	5.5	5.1	28.4	23.5	57.0	182	166
Tobacco and cotton	180	5.1	0.3	1.1	0.5	1.9	4	54
Vegetable and melon	300	8.0	0.3	1.4	1.3	3.0	10	79
Fruit, tree nut, and berry	548	5.7	0.8	4.9	11.7	17.4	96	180
Nursery, greenhouse, and floriculture	163	2.7	0.3	1.2	1.0	2.5	8	41
Other crop	1347	3.0	5.7	21.8	40.5	68.0	330	153
Beef cattle	5882	8.4	23.0	102.9	175.0	300.9	1419	428
Dairy	876	13.5	1.6	7.3	9.2	18.1	74	279
Hog	569	17.7	2.9	16.4	21.0	40.3	168	1256
Sheep, goat, wool, and mohair	2522	45.4	4.4	20.5	39.8	64.7	324	1165
Equine	2648	15.1	4.8	29.0	48.4	82.2	392	468
Poultry and egg	1185	21.8	4.2	14.2	25.5	43.9	207	807
Other animal	656	10.7	1.6	6.2	8.5	16.2	68	264
All injuries	26,570	12.3	93.0	372.7	537.2	1002.9	4322	463

*In millions. **The number of farms is an average from the 2002 and 2007 US Census of Agriculture. http://www.agcensus.usda.gov/Publications/2002/Volume_1,_Chapter_1_US/st99_1_050_050.pdf. http://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_1_US/st99_1_062_062.pdf.

cost estimates are conservative. We did not include possible parental household productivity loss due to youth injury. If included, the tangible costs would be $470 million. Losses in household work/chores were estimated based on the days lost and cost per day by age group and gender for all children. Since farm children do more chores than most children, we underestimate these losses. Depending on the agricultural cycle, injury to a youth also may cost the family farm operator more than just the hours spent to take the injured to the emergency department or visiting him/her in hospital. The operator's presence on the farm at that time may be critical for crop yield, so some injuries cause collateral economic damage. Since CAIS

TABLE 4. Annual Incidence and Costs of Nonfatal Farm Youth Injury in 2001–2006 by Age Group and Type of Farm, Ages 0–19 (2005 Dollars)

Type of farm	Annual incidence	Rate/1000 Farms**	Medical cost*	Total cost*	Annual incidence	Rate/1000 Farms**	Medical cost*	Total cost*
	Ages 00–04				Ages 05–09			
Total for the age group	2425	1.1	8438	105,275	5983	2.8	13,667	176,671
Grains and oilseeds	334	1.0	977	4575	696	2.0	1511	18,860
Tobacco and cotton	91	2.6	59	317	19	0.5	37	456
Vegetables and melons	75	2.0	62	529	37	1.0	13	115
Fruit, tree nuts, and berries	136	1.4	414	8659	96	1.0	161	1220
Nursery, greenhouse, and floriculture	28	0.5	53	865	24	0.4	164	1148
Other crops	55	0.1	50	195	530	1.2	454	3026
Beef cattle	888	1.3	3567	41,866	2182	3.1	5750	89,530
Dairy	138	2.1	254	7723	304	4.7	625	6849
Hogs	220	6.9	2002	24,711	116	3.6	332	5737
Sheep, goats, wool, and mohair	261	4.7	170	2256	636	11.4	1857	17,872
Equine	117	0.7	763	13,231	827	4.7	2311	28,142
Poultry and eggs	22	0.4	39	289	302	5.6	215	1484
Other animals	59	1.0	29	60	216	3.5	237	2233
	Ages 10–14				Ages 15–19			
Total for the age group	9554	4.4	28,639	319,788	8609	4.0	42,235	401,154
Grains and oilseeds	825	2.4	2648	32,496	966	2.8	3603	42,688
Tobacco and cotton	148	4.2	302	1299	49	1.4	45	190
Vegetables and melons	171	4.6	184	2107	279	7.4	312	1960
Fruit, tree nuts, and berries	167	1.7	203	7446	308	3.2	251	1183
Nursery, greenhouse, and floriculture	15	0.3	195	1589	261	4.4	426	2903
Other crops	968	2.2	5357	61,469	607	1.4	2282	17,735
Beef cattle	2425	3.4	9326	107,025	2542	3.6	29,802	240,822
Dairy	612	9.4	1101	8839	547	8.4	1237	9195
Hogs	324	10.1	585	8014	366	11.4	726	6384
Sheep, goats, wool, and mohair	1591	28.6	2093	19,945	829	14.9	1545	32,039
Equine	1320	7.5	1749	20,870	1198	6.8	1147	33,011
Poultry and eggs	602	11.1	3479	32,388	504	9.3	743	12,752
Other animals	387	6.3	1417	16,302	152	2.5	116	293

*In thousands. **The number of farms is an average from the 2002 and 2007 US Census of Agriculture.
http://www.agcensus.usda.gov/Publications/2002/Volume_1,_Chapter_1_US/st99_1_050_050.pdf.
http://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_1_US/st99_1_062_062.pdf.

excludes young contract laborers, to the extent they are injured, we have underestimated the burden of farm youth injuries. For lack of data, this estimate omits police and fire department costs, but we suspect those costs are minimal. Also the costs estimated in this study are costs of medically attended injury, not costs of injury incidents, because data on the costs of associated property damage are not available. This article excluded fatalities because data were not available to break them down into many of the categories tabulated.

The 1-year recall period of the CAIS survey creates recall bias—minor injuries may be underreported. For example, only 11% of injuries are reported in CAIS as nonmedically

TABLE 5. Annual Incidence and Costs of Nonfatal Farm Youth Injury in 2001–2006 by Age Group and Source of Injury, Ages 0–19 (2005 Dollars)

Source of injury	Annual incidence	Medical cost*	Total cost*	Annual incidence	Medical cost*	Total cost*
	Ages 00–04			Ages 05–09		
Total for the age group	2425	8438	105,275	5983	13,667	176,671
Chemicals and chemical products	87	455	2720	0	0	0
Containers	106	1331	19,762	119	1023	22,237
Furniture and fixtures	91	254	1448	199	499	9859
Machinery	35	130	6339	224	321	2249
Parts and materials	109	197	1252	245	322	4282
Persons, plants, animals, and minerals	258	441	3490	1059	2241	24,537
Structures and Surfaces	999	1741	27,174	2601	3642	58,199
Tools, instruments, and equipment	152	1630	24,168	436	1601	16,329
Vehicles	358	1355	12,295	804	3472	34,737
Other sources	231	904	6627	295	546	4243
	Ages 10–14			Ages 15–19		
Total for the age group	9554	28,639	319,788	8609	42,235	401,154
Chemicals and chemical products	43	77	284	63	100	812
Containers	114	98	1914	85	113	1264
Furniture and fixtures	143	563	7733	72	57	174
Machinery	216	412	2526	613	968	6464
Parts and materials	434	337	2316	713	861	3412
Persons, plants, animals, and minerals	2239	6875	78,025	2431	27,449	202,808
Structures and Surfaces	3373	7085	95,302	1960	4704	95,740
Tools, instruments, and equipment	787	1541	20,049	646	566	2407
Vehicles	1849	11,029	101,422	1272	5407	56,295
Other sources	355	623	10,218	753	2008	31,777

*In thousands.

treated. To the extent that nonmedically treated injury is underreported, the overall mean cost of injury is overestimated. This study shares the limitations of the unit costs we used. Notable among those are the assumption that permanent disability rates are the same for children and adults with comparable injuries and reliance on aging data on the pattern of medical costs beyond 30 months post injury. Because the unit costs used as input to the process do not have confidence intervals, our estimates of mean cost variance for different categories were based on the injury severity variance of each category (e.g., the injury severity variance in dairy farms).

Youth farm injuries are comparable to other occupational injuries, which makes them much more serious than the average youth injury. Their medical care costs average $3500, which is quite close to the $3641 average for all days-away-from-work (DAFW) agricultural injuries and the $3696 average for all DAFW occupational injuries.[17] That average is higher than the $2728 average for occupational injuries of teenagers[18] and much higher than the $1388 average for all medically attended nonfatal unintentional childhood injuries.[2]

For several reasons, work injuries accounted for just 29% of the youth injury incidence and costs on farms. Some farmers, recognizing farm work is hazardous, do not let their children work on the farm. Even a child who works on the farm may only work a few hours a week resulting in more hours of exposure to home than farm injury risks. Also, 29% of the injuries are to visiting children and only 12% of their injuries are work related. Finally, 12% of all injuries and 24% of related costs come from assaults; these rarely are associated with youth agricultural work.

TABLE 6. Annual Incidence and Costs of Nonfatal Farm Youth Injury in 2001–2006 by Age Group and Event, Ages 0–19 (2005 Dollars)

Injury event	Annual incidence	Medical cost*	Total cost*	Annual incidence	Medical cost*	Total cost*
	Ages 00–04			Ages 05–09		
Total for the age group	2425	8438	105,275	5983	13,667	176,671
Contact with objects and equipment	562	1325	19,005	1221	2205	14,086
Falls	1278	4741	67,962	3090	5814	104,260
Bodily reaction and exertion	5	56	384	4	3	7
Exposure to harmful substances or environments	161	1227	7980	35	14	58
Transportation incidents	241	920	7971	676	3309	33,717
Fires and explosions	0	0	0	73	130	465
Assaults and violent acts	137	133	1264	739	1723	15,873
Other events or exposures	41	36	710	146	469	8204
	Ages 10–14			Ages 15–19		
Total for the age group	9554	28,639	319,788	8609	42,235	401,154
Contact with objects and equipment	2279	3027	21,897	3122	5166	54,357
Falls	3165	8688	123,684	1936	5039	103,463
Bodily reaction and exertion	352	447	3904	567	2113	14,694
Exposure to harmful substances or environments	356	391	1103	341	903	4774
Transportation incidents	1709	10,900	100,853	1209	5333	55,018
Fires and explosions	19	33	125	65	220	1643
Assaults and violent acts	1252	4586	57,857	998	23,070	165,461
Other events or exposures	423	567	10,365	370	391	1744

*In thousands.

The past two decades have brought an influx of federal and private funds into the prevention of childhood agricultural injuries. With funding from the National Institute for Occupational Safety and Health (NIOSH), guidelines were established for children working on family farms,[19] for youth employed on nonfamily farms,[20] for creating safe play areas on farms[21] and for agritourism farms catering to child visitors.[22] Research and programmatic activities have primarily addressed youth-based educational programs and many of these educational interventions reference the guideline documents. A 2004 systematic review of intervention effectiveness[23] reported a dearth of methodologically rigorous evaluation research and no clear indicators of prevention effectiveness. Subsequent to the 2004 review, Gadomski et al.[24] reported that farms on which tasks for children ages 7–19 years were consistent with North American Guidelines for Children's Agricultural Tasks (NAGCAT) experienced only half the number of injuries compared to a control group. Yet, the same study noted that for many of the injuries, no applicable guidelines existed. Regardless of the task assigned to a youth, if the working conditions are inherently unsafe for adults, the risk of injury or death is equal or greater for the child.

When the farm is also the home for children younger than 7 years, safety professionals encourage a complete separation from the adult work setting. Off-site child care is the ideal. In contrast to their urban counterparts, farm parents are less likely to use child care services for a variety of reasons, including cost. Child care services for a preschooler may range from $5000 to $10,000 annually. The absence of affordable, high quality, off-farm child care programs is a major challenge in protecting young, nonworking children on farms. When off-site child care is not an option, the creation and use of a supervised, safe play area on the farm is recommended.[21]

CONCLUSION

Although the number and rate of childhood agricultural injuries has declined over the past decade, the economic impact of these events continues to extol major costs for the families of injury victims and the health care system. The average cost of medical treatment for a childhood agricultural injury is almost $4000. Although farm families often have limited financial resources, this study suggests that adopting safe practices associated with working and nonworking children on farms yields economic benefits.

REFERENCES

1. Miller TR, Romano EO, Spicer RS. The cost of childhood unintentional injuries and the value of prevention. *Future Child.* 2000;10:137–163.

2. Miller TR, Finkelstein AE, Zaloshjna E, Hendrie D. The cost of child and adolescent injuries and the savings from prevention. In: Liller K, ed. *Injury Prevention for Children and Adolescents: Research, Practice, and Advocacy*. Washington, DC: American Public Health Association; 2005:15–64.

3. Leigh JP, Waehrer GM, Miller TR, Keenan C. Costs of occupational injury and illness across industries. *Scan J Work Environ Health.* 2004;30:199–205.

4. Hendricks KJ, Goldcamp EM. Injury surveillance for youth on farms in the U.S., 2006. *J Agric Saf Health.* 2010;16:279–291.

5. National Institute for Occupational Safety and Health. *Injuries to Youth on Farms and Safety Recommendations, U.S. 2006*. Washington, DC: Center for Disease Control; February 2009 NIOSH Publication No. 2009–117.

6. Hendricks KJ, Hendricks SA. Changing farm injury trends by sex for youth living on U.S. farms, 1998–2006. *J Rural Health.* 2010;26:182–188.

7. Rivara FP. Fatal and non-fatal farm injuries to children and adolescents in the United States, 1990–1993. *Inj Prev.* 1997;3:190–194.

8. Gerberich SG, Gibson RW, French LR, et al. Injuries among children and youth in farm households: regional rural injury study. *Inj Prev.* 2001;7:117–122.

9. Leigh JP, McCurdy SA, Schenker MB. Costs of occupational injuries in agriculture. *Public Health Rep.* 2001;116:235–248.

10. National Institute for Occupational Safety and Health. *Childhood Agricultural Injury Survey*. 2004. Available at: http://www.cdc.gov/niosh/docs/2004-146/appendix/ap-a/ap-a-4.html. Accessed November 23, 2010.

11. Bureau of the Census. *The Methods and Materials of Demography*. Vol 1. Washington, DC: Shyrock, Siegal, and Associates; 1975.

12. Corso PC, Finkelstein E, Miller TR, Fiebelkorn IA, Zaloshnja E. Incidence and lifetime costs of injuries in the United States. *Inj Prev.* 2006;12:212–218.

13. Finkelstein EA, Corso PC, Miller TR, Fiebelkorn IA, Zaloshnja E, Lawrence BA. *Incidence and Economic Burden of Injuries in the United States, 2000*. New York: Oxford University Press; 2006.

14. Gold MR, Siegel JE, Russell LB, Weinstein MC, eds. *Cost-effectiveness in Health and Medicine: Report of the Panel on Cost-Effectiveness in Health and Medicine*. New York: Oxford University Press; 1996.

15. Miller TR, Pindus NM, Douglass JB, Rossman SB. *Databook on Nonfatal Injury: Incidence, Costs, and Consequences*. Washington, DC: The Urban Institute Press; 1995.

16. Haddix AC, Teutsch SM, Corso PS. *Prevention Effectiveness, A Guide to Decision Analysis and Economic Evaluation*. 2nd ed. New York: Oxford University Press; 2003.

17. Miller T, Waehrer G, Leigh JP, et al. *The Costs of Occupational Injuries: A Microdata Approach (Final Report to the National Institute for Occupational Safety and Health)*. Calverton, MD: Pacific Institute for Research and Evaluation; 2000.

18. Miller T, Waehrer G. Costs of occupational injuries to teenagers. *Inj Prev*. 1998;4:211–217.

19. Lee B, Gallagher SS, Marlenga B, Hard D. *Childhood Agricultural Injury Prevention: Progress Report and Updated National Action Plan from the 2001 Summit*. Marshfield, WI: Marshfield Clinic; 2002.

20. Fisher RM, Miller M, Mulhern B, Lee BC. *Safety Guidelines for Hired Adolescent Farm Workers*. Marshfield, WI: Marshfield Clinic; 2009.

21. Esser N, Heiberger S, Lee B. *Creating Safe Play Areas on Farms*. Marshfield, WI: Marshfield Clinic; 2003.

22. Humann MJ, Lee BC. *Agrotourism Health and Safety Guidelines for Children*. Marshfield, WI: Marshfield Clinic; 2007.

23. Hartling L, Brison RJ, Crumley ET, Klassen TP, Pickett W. A systematic review of interventions to prevent childhood farm Injuries. *Pediatrics.* 2004; e483–e496. Available at: http://pediatrics.aappublications.org/cgi/content/. Accessed November 23, 2010.

24. Gadomski A, Ackerman S, Burdick P, Jenkins P. Efficacy of the North American guidelines for children's agricultural tasks in reducing childhood agricultural injuries. *Am J Public Health.* 2006;96:722–727.