A National Overview of Youth and Injury Trends on U.S. Farms, 2001-2014

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HIGHLIGHTS

- The total number of injuries to all youth on farms consistently declined during the 14-year period from 2001 to 2014.
- Injuries to household farm youth, after initial declines, increased in 2012 and 2014.
- Although progress in farm youth safety has been made, farms continue to be hazardous places for youth.

ABSTRACT. *The National Institute for Occupational Safety and Health (NIOSH) conducted injury surveillance for youth on U.S. farms for two decades to measure childhood injury burden, track injury trends, and monitor hazardous injury exposures. The Childhood Agricultural Injury Survey (CAIS), a regionally stratified telephone survey, collected injury and demographic data for all youth less than 20 years of age on U.S. farms. Results from the 2014 survey are provided. Trend analyses for all survey years were conducted using a Poisson regression model with generalized estimating equations. Rate ratios with corresponding 95% confidence intervals were calculated from the model. In 2014, there were an estimated 11,942 youth farm injuries. Of these, 63% occurred to household youth. Youth between the ages of 10 and 15 incurred the most injuries, and 34% of the injuries were work-related. The total number of injuries to all youth on farms consistently declined during the 14-year period from 2001 to 2014, with annual injury rates ranging from 13.5 to 5.7 per 1,000 farms. The injury rates for household youth decreased through 2009 but increased slightly in 2012 and 2014. Farms continue to be hazardous environments for youth. Although there has been a significant decrease in the overall numbers and rates of youth farm injuries over the past decades, researchers should continue to monitor areas that remain a concern. One area that is specifically troublesome is the increase in injury rates observed for household youth in 2014.*

Keywords. *Agriculture, Farm, Injury, Trends, Youth.*

The National Institute for Occupational Safety and Health (NIOSH) surveillance efforts for youth in agriculture were initiated, in part, by the 1991 Surgeon General's Conference on Agricultural Safety and Health in Des Moines, Iowa (NIOSH, 1992).

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That conference included a session focused on the risks faced by youth and adults involved in agricultural production. Following the conference, a Childhood Agricultural Injury Prevention symposium was held in Marshfield, Wisconsin, that sought to develop consensus on relevant research, education, policy, and other interventions aimed toward reducing injuries for children on farms. From that symposium, a core group of participants formed the National Committee for Childhood Agricultural Injury Prevention (NCCAIP). The committee developed new recommendations based on current injury data, along with other scientific evidence. They also refined and prioritized recommendations to be clearly understood and acted upon by relevant individuals and agencies. In 1996, NCCAIP published these recommendations as a National Action Plan to promote the health and safety of children exposed to agricultural hazards (NCCAIP, 1996).

One of the recommendations of the National Action Plan was that "NIOSH should develop, implement, monitor, and evaluate a comprehensive childhood agricultural injury prevention program involving injury data collection, education, policy, research, and other initiatives that involve linkages across federal, regional, and state levels" (NCCAIP, 1996). Acting on this recommendation, NIOSH developed the Childhood Agricultural Injury Survey (CAIS) as one part of their Childhood Agricultural Injury Prevention Initiative.

Since the development of the 1996 National Action Plan, NIOSH has collected nearly two decades of injury and hazardous exposure data for youth on farms in the U.S. The updated National Action Plan of 2012 cited the NIOSH CAIS surveillance system as a "hallmark of success" with CAIS analyses and reports providing valuable insights leading to more focused interventions (Lee et al., 2012). In 2015, NIOSH made the decision to refocus its childhood agriculture safety and health efforts toward intervention and prevention strategies. This led to the discontinuation of the CAIS and other NIOSH agricultural surveillance efforts following completion of the 2014 survey.

This article presents an overview of the non-fatal youth injury and exposure data collected from the 2014 CAIS. Additionally, this article examines household youth injury trends for the entire CAIS series of six surveys from 2001 to 2014.

Materials and Methods

In 2015, NIOSH collaborated with the USDA National Agricultural Statistics Service (NASS) to conduct the final CAIS. In past surveys, the CAIS was administered as a regionally stratified telephone survey of 50,000 farms across the U.S. For the final year of data collection, the sample size was increased to 75,000 farms. The CAIS collected information on farm-related injuries to youth less than 20 years of age that occurred during the 2014 calendar year. Interviews were conducted between January and April 2015. Sampling was based on the Bureau of Census geographic regions and the value of farm sales.

For this study, a farm was defined as any operation from which $1,000 or more of agricultural products were produced or sold, or normally would have been sold, during the census year. An injury was defined as any event occurring on the farm that required at least four hours of restricted activity or required an individual to seek medical attention. Information was collected for both work and non-work injuries occurring to youth on farms. This included youth who were living on the farm, visited the farm at least once, or were hired directly by the farm operator. Injuries to youth contract laborers were not collected in this study. A work-related injury was defined as any injury that occurred while performing activities that had a direct impact on the farm as a business. This work-related definition

included what are commonly considered “childhood chores” that were performed in support of the farm. Whether the activity was performed for pay and the age of the injured youth were not considered relevant to the determination of work-relatedness.

The data collected for the CAIS were primarily self-reported by either the female or male head of household. If an injury occurred to a youth living in the household who was 16 years of age or older, the youth was asked to answer the injury section of the survey. All questions related to the occurrence of an injury, work status, and the characteristics of the injury event were subject to the interpretation of the respondent.

In addition to the total number of youth injuries, common injury information, such as the affected body part, type of injury, location on the farm where the injury occurred, and an injury narrative, were collected for up to four youth injuries per farm, beginning with the most recent injury. The collection of detailed injury information was limited to reduce respondent burden. The injury narratives were examined by NIOSH staff to code the primary and secondary sources of injury and the injury event according to the Occupational Injury and Illness Classification System (OIICS v2.01; BLS, 2012).

Sampling weights were calculated based on the total number of farms responding by geographical region, the number of farms reported in the 2012 Census of Agriculture for each region, and the gross value of farm sales. All estimates and variances for both the injury and demographic data were calculated using the SAS SurveyMeans and SurveyFreq procedures (SAS, 2020). These SAS procedures use the sampling weights, adjusting for region and farm, to produce national estimates. Multiple youth from an individual farm were treated as a cluster in these analyses. Estimates and 95% confidence intervals (CIs) are presented where the relative standard error does not exceed 33% of the estimate. Injury rates were calculated as the estimated number of injuries divided by the estimated number of youth. All rates for household and hired youth are expressed in terms of 1,000 youth.

All trend analyses were restricted to youth living on farms (i.e., household youth). Other youth populations (i.e., visiting youth, relatives, etc.) were not included in the trend analyses due to a lack of demographic and exposure data. The trend analyses of these data used a Poisson regression model using generalized estimating equations (GEEs) obtained with the SAS GENMOD procedure (SAS, 2020). Rate ratios with corresponding 95% CIs were calculated from the model to compare the rate of injuries in each survey year to those in 2001, which served as the baseline. GEEs were needed to adjust the CIs of the rate ratios to control for the estimated correlation resulting from multiple youth living on the same farm. This estimated correlation was assumed to be identical across all farms. Significance of the trends during the entire study period was assessed using orthogonal linear and quadratic contrast statements in the GEE model. Adjustments to the orthogonal linear and quadratic contrasts were made to account for the unequal spacing of years in the study period.

Results and Discussion

2014 CAIS Demographics

The 2014 CAIS used a random sample of 75,000 farming operations obtained from the 2012 Census of Agriculture sampling frame. Of the original sample, 53,364 farms were able to be contacted. Of those contacted farms, 2,892 were determined to be out of business, 14,911 refused to participate, and 35,561 completed the survey, for an adjusted response rate of 70.5%, where the adjusted response rate = (completes + out of business) ÷ (total – non-contacts). In 2014, more than two million farms were in operation in the U.S. (table 1).

Table 1. National estimates of U.S. farms with youth, 2014.

Category	Number of Farms	95% Confidence Interval (CI)
Total U.S. farms	2,084,000	±14,688
Farms with any youth	1,500,689	±16,881
Farms with household youth	446,420	±12,515
Farms with hired youth	114,442	±6,049
Farms with visiting youth	1,364,664	±17,013

Of the CAIS respondents, 72% reported having youth less than 20 years of age on their farm at some point during 2014. In addition, 21% of the farms had household youth residents, 5% had directly hired youth, and 65% had visiting youth, including both relatives and non-relatives (table 1).

All Youth

In 2014, there were an estimated 25 million youth (95% CI ±2.1 million) less than 20 years of age on farms in the U.S. Of these youth, 95% (23.9 million; 95% CI ±2.2 million) were visitors, with 41% (9,809,495; 95% CI ±735,386) of visitors reporting a familial relationship to the farm operator. An estimated 265,604 youth (95% CI ±18,553) were hired directly by the farm operator to perform work on the farm. An estimated 874,539 youth (95% CI ±19,514) lived on the farm (i.e., household youth). Of the 10 million visiting youth relatives, 8% (793,518; 95% CI ±133,184) performed unpaid work on the farm while visiting. Additional demographic data for 2014 and previous years of the CAIS can be found on the NIOSH Childhood Agricultural Injury Survey web page (NIOSH, 2018).

Household Youth

Of the estimated 892,836 household youth, approximately 50% were male and 47% were female (table 2). Of the household youth, 51% reported performing work on the farm, 25% reported riding a horse for work or recreation, 37% operated an all-terrain vehicle (ATV) for work or recreation, and 25% operated a tractor. An estimated 55% of youth lived on livestock farms, with the majority (281,210; 95% CI ±14,872) residing on cattle farms. An estimated 404,968 youth lived on crop operations. By value of farm sales, most youth (47.6%) lived on farms with less than $10,000 in annual sales, 26.6% lived on farms with $10,000 to $99,999 in annual sales, and 25.8% (95% CI ±9,996) lived on farms earning more than $100,000. Additional demographic data from the 2014 CAIS, as well as data from previous surveys, can be found on the NIOSH Childhood Agricultural Injury Survey web page (NIOSH, 2018).

Hired Youth

Youth hired directly by the farm operator (i.e., contract laborers were not included) comprised about 1% of all youth on farms and accounted for 18% of youth working, regardless of pay, on the farm (table 2). Of the hired youth, 56% (147,831; 95% CI ±13,042) worked on crop farms and 44% (117,773; 95% CI ±9,953) worked on livestock operations. Of the hired youth, 81% (214,561; 95% CI ±11,001) were male. The average age of youth hired directly on farms was 16.9 years. Of the hired youth, 28% (73,736; 95% CI ±6,664) were reported to have operated a tractor, 28% (74,101; 95% CI ±7,846) rode an ATV, and 10% (26,087; 95% CI ±4,804) rode a horse in the course of their employment.

Table 2. Estimates of household and hired youth less than 20 years old on U.S. farms, 2014 (estimates may not sum to total due to rounding; CI = confidence interval, and NR = estimate is not reportable).

		Household Youth		Hired Youth	
		Estimate	95% CI	Estimate	95% CI
Total youth		892,836	±28,879	265,604	±18,553
Gender	Males	442,738	±13,359	214,561	±11,001
	Females	416,784	±13,649	42,521	±6,591
	Unknown	33,315	±6,637	8,524	-
Age	Less than 10 years	305,193	±7,509	NR	-
	10-15 years	310,153	±12,164	40,669	±5296
	16-19 years	234,418	±9,775	203,400	±11,450
	16-17 years	129,052	±6,956	106361	±9,549
	18-19 years	105,366	±6,370	97,040	±7,466
	Unknown	43,072	±7,503	NR	-
Type of farm	Crop	404,968	±16,719	147,831	±13,042
	Livestock	487,868	±19,557	117,773	±9,953
Work exposure	Yes	453,978	±16,246	214,561	±11,001
	No	406,218	±15,570	0	-
	Unknown	32,641	±6,944	0	-
Horse	Yes	220,670	±12,587	26,087	±4,804
	No	638,525	±18,253	232048	±12,791
	Unknown	33,641	±6,974	7,468	-
Tractor	Yes	227,618	±9,867	73,736	±6,664
	No	555,488	±17,583	184,083	±12,897
	Unknown	109,729	±9,151	7,785	-
ATV	Yes	331,650	±12,952	74,101	±7,846
	No	450,944	±17,375	184,003	±13,820
	Unknown	110,243	±9,161	7,500	-
Value of sales	<$10,000	425,224	±23,091	76,994	±11,147
	$10,000 to $99,999	237,364	±10,335	73,009	±7,019
	$100,000+	230,248	±9,996	115,600	±10,907

2014 CAIS Injuries

All Youth

There were an estimated 11,942 injuries to youth on U.S. farms in 2014 (table 3). Of these injuries, 7,469 occurred to household youth and 4,473 (95% CI ±1,164) occurred to youth either hired directly by the farm operator or visiting youth. Additional injury data from the 2014 CAIS, as well as data from previous surveys, can be found on the NIOSH Childhood Agricultural Injury Survey web page (NIOSH, 2018).

Of all youth injuries, 58% occurred to males. Youth between the ages of 10 and 15 incurred the most injuries, and 34% of injuries were work-related. Of youth injuries, 59% occurred on livestock farms. By type of farm, youth on cattle farms sustained 3,424 injuries (95% CI ±976), which is almost half (49%) of all injuries on livestock farms and 29% of total youth farm injuries. When examining the number of injuries by region, the South had the highest proportion of injuries (40%), followed by the Midwest (35%). For all youth, the most common types of injuries were fractures or broken bones, followed by cuts and lacerations, and contusions (table 4). The upper extremities were the most commonly injured part of the body, followed by the head, skull, face, and neck. The injury patterns were very similar for household youth.

Table 3. Estimates of injuries to youth less than 20 years old on U.S. farms for all youth and household youth, 2014 (estimates may not sum to total due to rounding; CI = confidence interval).

		All Youth		Household Youth	
		Estimate	95% CI	Estimate	95% CI
Total injuries		11,942	±1,182	7,469	±1,303
Gender	Males	6,942	±1,213	4,365	±1,115
	Females	5,000	±1,370	2,833	±1,105
Age group	<10 years	3,220	±1,058	1,695	±725
	10-15 years	5,376	±1,327	4,042	±1,233
	16-19 years	3,010	±982	1,731	±817
Work status	Work	4,036	±1,021	2,972	±982
	Non-work	7,906	±1,421	4,497	±1,241
Region[a]	Northeast	1,137	±204	500	±122
	Midwest	4,233	±621	3,192	±808
	South	4,803	±825	2,582	±825
	West	1,769	±535	1,194	±596
Type of farm	Crop	4,935	±1,227	3,464	±1,105
	Livestock	7,007	±1,403	4,005	±1,174

[a] Northeast = Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont.
Midwest = Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin.
South = Alabama, Arkansas Delaware, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, West Virginia, and Virginia.
West = Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming

Table 4. Estimates of farm injury characteristics for youth less than 20 years old on U.S. farms for all youth and household youth, 2014 (estimates may not sum to total due to rounding; CI = confidence interval, and NR = estimate is not reportable).

		All Youth		Household Youth	
		Estimate	95% CI	Estimate	95% CI
Total injuries		11,942	±1,182	7,469	±1,303
Type of injury	Fracture	3,277	±1,070	2,381	±927
	Laceration	2,541	±982	1,514	±780
	Contusion	954	±570	459	±329
	Other injuries	5169	±1,266	3,114	±1,074
Body part	Lower extremities	2021	±876	1,503	±753
	Upper extremities	4594	±1,174	2,469	±894
	Head, skull, face, and neck	3182	±1,062	2,156	±994
	Other body parts	2144	±945	1,341	±741
Primary source	Persons, plants, animals, minerals	4,630	±1,390	2,446	±1,174
	Vehicles	3,381	±1,072	2,183	±872
	Machinery	773	±512	NR	NR
	Tools, instruments, equipment	532	±343	NR	NR
	Other sources[a]	2,625	±890	1,846	±770
Event	Transportation incidents	4,359	±1,299	2,654	±1,064
	Contact with objects and equipment	3,010	±933	2,383	±913
	Violence, injury by person or animal	1,531	±855	NR	NR
	Falls, slips, trips	1,422	±719	881	±553
	Other events[b]	1,621	±759	950	±617

[a] Other sources include chemicals and chemical products, containers, furniture and fixtures, parts and materials, structures and surfaces, and nonclassifiable sources.
[b] Other events include fires and explosions, exposure to harmful substances or environments, overexertion and bodily reaction, and nonclassifiable events.

Over one-third of the injuries were animal-related (3,827; 95% CI ±1,331). Horses were the primary source of injury in 86% (3,276; 95% CI ±1,311) of animal-related injuries. Transportation incidents were the most common injury event, accounting for 37% of all injuries, followed by contact with objects and equipment, violence and other injuries by persons or animals, and falls, slips, and trips.

Work Injuries

Approximately 34% of injuries to all youth were work-related (4,036; 95% CI ±1,021), with an injury rate of 5.6 per 1,000 working youth. Males incurred 71% (2,850; 95% CI ±876) of all work injuries, and youth between the ages of 15 and 17 experienced the largest proportion (41%) of work injuries (1,655; 95% CI ±717), followed by youth age 14 and younger (1,444; 95% CI ±698) and youth age 18 to 19 (938; 95% CI ±598). The distributions of work-related injuries by type of farm were similar, with youth on crop farms incurring 53% (2,135; 95% CI ±882) of work-related injuries. An estimated 21% (859; 95% CI ±488) of work-related injuries occurred to hired youth. A more detailed analysis of injuries to hired youth could not be presented due to confidentiality concerns.

Non-Work Injuries

An estimated 7,906 (95% CI ±1,421) youth injuries were not related to work. Unlike the work-related injuries, we did not see the same gender disparity among non-work injuries. Males incurred 52% (4,092; 95% CI ±1,158) of the non-work injuries compared to females at 48% (3,814; 95% CI ±1,276). Consistent with the overall injuries, youth between the ages of 10 and 15 (3,573; 95% CI ±1,239) experienced the most non-work injuries, followed by youth less than 10 years of age (2,856; 95% CI ±1,043). Horses (2,606 95% CI ±1,188) were the primary source for one-third of the non-work injuries. Of the youth injured in non-work activities, 57% (4,497; 95% CI ±1,241) were household youth.

CAIS Trends

The number of U.S. farms in operation ranged from 1.9 to 2.1 million during the 14-year period covered by the CAIS. Over that time period, the number of respondents who reported having youth less than 20 years of age on their farms ranged from a high of 80% in 2001 to 72% in 2014. Farms reporting youth living in the household ranged from a low of 21% in 2014 to a high of 32% in 2001. Respondents who reported hiring youth fluctuated, with a high of 8% in 2001 and a low of 4.5% in 2009.

The total number of injuries to all youth on farms (including household, hired, and visiting youth) consistently declined during the 14-year period, with injury rates ranging from a high of 13.5 injuries per 1,000 farms in 2001 to a low of 5.7 per 1,000 farms in 2014 (fig. 1). Household youth comprised 48% to 76% of the total number of injuries during each of the survey periods (fig. 1).

Household Youth Injury Trends

The number of household youth injuries declined through 2009, consistent with the trends observed for all youth on farms. However, the number of injuries to household youth remained relatively constant during the last three survey periods (2009, 2012, and 2014), while the number of injuries for all youth continued to decline. The injury rates for household youth decreased through 2009 but increased slightly in 2012 and 2014 (fig. 1). The overall linear trend for all household youth declined significantly ($p < 0.0001$) over the study period. However, the significance of the quadratic trend ($p = 0.041$) demonstrated

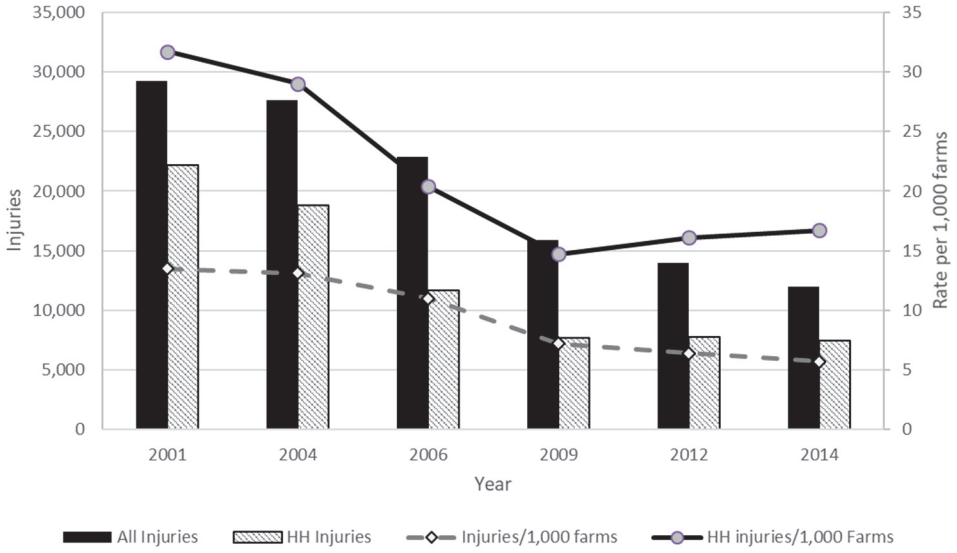

Figure 1. Total number of injuries and injury rates per 1,000 farms for all youth and household (HH) youth on U.S. farms, 2001-2014.

that the rates were beginning to increase toward the end of the study period (table 5). Similar trends were observed for work-related injuries (data not shown), which were significant in both the linear ($p = 0.0007$) and quadratic models ($p = 0.0385$).

Males accounted for the majority of household youth injuries in each survey period, with the percentage of injuries among females ranging from 33% to 47%. When examining the injury rates for household youth by gender, although the injury rates for both males and females were lower in 2014 than when the CAIS began in 2001, neither gender showed a consistent decline. The injury rates for female household youth ranged from a high of 15.4 in 2001 to a low of 6.5 in 2009 (fig. 2). In 2012, the rate for household females increased to 8.1, before declining once again in 2014 to 6.8. For household males, the injury rate was at its highest in 2001 at 17.9. The male injury rate declined in each of the next three survey periods to a low of 8.7 in 2009, before increasing in 2012 and 2014.

A comparison of age groups among household youth showed that youth ages 10 to 15 accounted for a greater number of injuries and had higher injury rates than other age groups. Figure 3 shows the household injury rates by age group during each survey period, with injury rates increasing during the last survey period (2014) for all household youth 10 years of age and older. Although each age group showed a significant decrease in the linear model (table 5), household youth between the ages of 10 and 15 also had a significant quadratic trend ($p = 0.0362$). When examining the trends for the combination of gender and age, all age groups for both genders showed a significant decrease in the linear trend, except for household males less than 10 years of age. When examining the quadratic trend, only males between the ages of 10 and 15 showed a significant trend ($p = 0.051$), which indicates a significant increase in the injury rates for this population in 2014.

Table 5. Rate ratios by year for injuries to household youth less than 20 years old on U.S. farms by age and gender with corresponding p-values for linear and quadratic trends.

		Year	Rate Ratio (and 95% CI)	Linear Trend p-Value	Quadratic Trend p-Value
All household youth	All ages	2001	-		
		2004	0.90 (0.71, 10.15)		
		2006	0.64 (0.49, 0.84)		
		2009	0.46 (0.33, 0.63)		
		2012	0.49 (0.35, 0.69)		
		2014	0.50 (0.37, 0.68)	<0.0001	00.041
	<10 years	2001	-		
		2004	1.16 (0.73, 1.86)		
		2006	0.60 (0.73, 1.86)		
		2009	0.48 (0.25, 0.89)		
		2012	0.82 (0.47, 1.42)		
		2014	0.42 (0.24, 0.76)	0.0023	0.639
	10-15 years	2001	-		
		2004	0.63 (0.44, 0.90)		
		2006	0.60 (0.40, 0.90)		
		2009	0.42 (0.26, 0.68)		
		2012	0.36 (0.20, 0.63)		
		2014	0.49 (0.31, 0.76)	<0.0001	0.0362
	16-19 years	2001	-		
		2004	1.24 (0.80, 1.93)		
		2006	0.81 (0.47, 1.39)		
		2009	0.57 (0.31, 1.03)		
		2012	0.47 (0.25, 0.90)		
		2014	0.70 (0.40, 1.20)	0.0035	0.4897
Male household youth	All ages	2001	-		
		2004	0.92 (0.67, 1.27)		
		2006	0.80 (0.56, 1.13)		
		2009	0.52 (0.34, 0.79)		
		2012	0.51 (0.33, 0.76)		
		2014	0.62 (0.42, 0.90)	<0.0001	0.206
	<10 years	2001	-		
		2004	1.06 (0.54, 2.06)		
		2006	0.68 (0.35, 1.34)		
		2009	0.72 (0.31, 1.65)		
		2012	0.96 (0.48, 1.94)		
		2014	0.60 (0.27, 1.33)	0.2593	0.8662
	10-15 years	2001	-		
		2004	0.68 (0.42, 1.11)		
		2006	0.79 (0.47, 1.33)		
		2009	0.31 (0.15, 0.63)		
		2012	0.30 (0.14, 0.65)		
		2014	0.57 (0.33, 1.00)	0.0008	0.051
	16-19 years	2001	-		
		2004	1.38 (0.80, 2.35)		
		2006	0.99 (0.53, 1.83)		
		2009	0.80 (0.41, 1.56)		
		2012	0.50 (0.25, 1.03)		
		2014	0.81 (0.42, 1.57)	0.0341	0.8896

Table 5 (continued). Rate ratios by year for injuries to household youth less than 20 years old on U.S. farms by age and gender with corresponding p-values for linear and quadratic trends.

		Year	Rate Ratio (and 95% CI)	Linear Trend p-Value	Quadratic Trend p-Value
Female household youth	All ages	2001	-		
		2004	0.88 (0.61, 1.26)		
		2006	0.47 (0.30, 0.74)		
		2009	0.40 (0.25, 0.64)		
		2012	0.50 (0.30, 0.84)		
		2014	0.40 (0.25, 0.64)	<0.0001	0.0801
	<10 years	2001	-		
		2004	1.27 (0.66, 2.42)		
		2006	0.50 (0.26, 0.98)		
		2009	0.24 (0.10, 0.56)		
		2012	0.71 (0.30, 1.65)		
		2014	0.28 (0.12, 0.62)	0.0006	0.3879
	10-15 years	2001	-		
		2004	0.57 (0.33, 0.98)		
		2006	0.39 (0.19, 0.78)		
		2009	0.54 (0.29, 1.01)		
		2012	0.42 (0.19, 0.95)		
		2014	0.39 (0.19, 0.81)	0.0008	0.2046
	16-19 years	2001	-		
		2004	1.11 (0.55, 2.27)		
		2006	0.60 (0.22, 1.61)		
		2009	0.30 (0.09, 1.00)		
		2012	0.44 (0.14, 1.32)		
		2014	0.59 (0.24, 1.39)	0.0323	0.2198

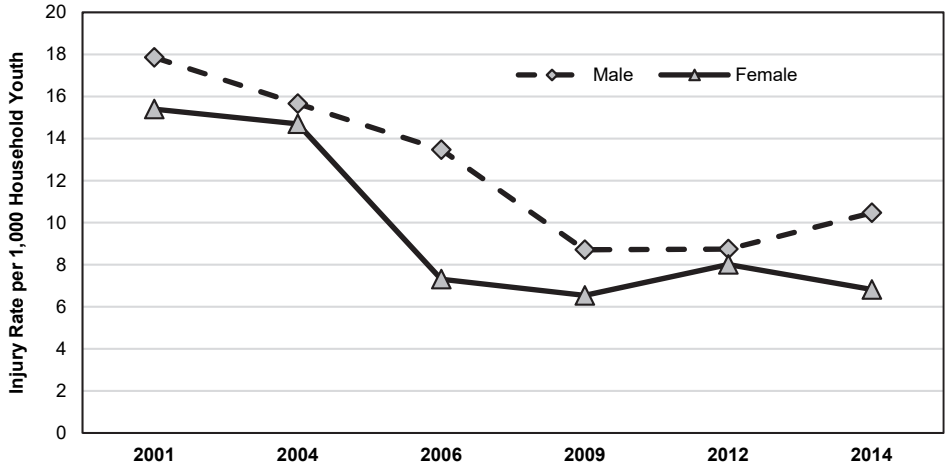

Figure 2. Injury rates for household youth on U.S. farms by year and gender, 2001-2014.

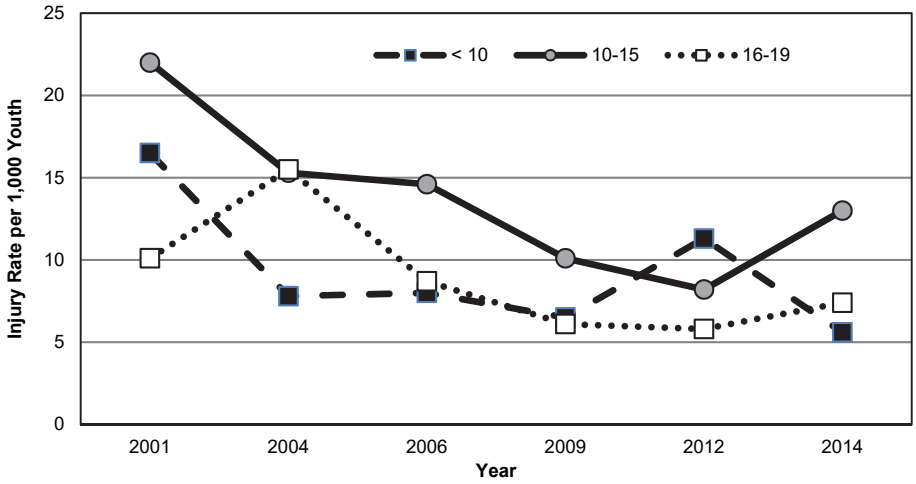

Figure 3. Injury rates for household youth on U.S. farms by year and age group, 2001-2014.

Discussion

NIOSH began the CAIS to provide national surveillance for youth on farms. Over the six survey cycles conducted, the same areas of concern emerged: injuries to youth living on farms regardless of work status, injuries to youth less than 16 years of age, and animal- and transportation-related injuries. Although the data indicate that progress has been made in the overall area of childhood agricultural injuries, the etiology of the injuries has not changed.

In each year of the survey, youth between the ages of 10 and 15 experienced the highest number of injuries among all youth on farms. Although each age group experienced an overall decrease in injury rates from the beginning of the survey in 2001 until the final survey in 2014, annual rates increased at some point in the cycle of surveys. The injury rate for household youth between 10 and 15 years of age exhibited a steady decline from 2001 to 2012 before increasing in 2014. Similarly, the rate for youth less than 10 years of age declined initially, before increasing in 2012.

In part, to address the high rate of injury among the youngest farm youth, the National Children's Center for Rural and Agricultural Health and Safety (NCCRAHS) published a comprehensive guide for designing and building safe play areas on farms (Esser et al., 2012). The guide includes recommendations for appropriate levels of supervision based on the age of the children, the number of children present, and the type and location of play. Safe play areas provide separation between work and non-work areas of the farm and are an alternative to bringing young children into work areas when off-site childcare is not available.

While there have been declines in the overall number of injuries, animals and vehicles have been the most common primary source of injury across all surveys (NIOSH, 2018). The unpredictability of animal behavior coupled with the presence of youth on farms presents a distinct challenge for farm safety professionals. Horses are also common on both livestock and crop farms and are used for both work and recreation by youth. In 2014, 25% of household youth reported riding a horse for either work or recreation, and horses were

the primary source in 86% of animal-related injuries. The use of protective equipment, such as helmets for riders, could reduce the number and severity of many horse-related injuries (Bier et al., 2018; Carmichael et al., 2014). Previous research has shown that, without a helmet, the injury severity associated with being thrown from a horse is comparable to being struck by a car (Bond et al., 1995).

In addition to horses, the CAIS data consistently show cattle farms to have a large proportion of youth injuries among livestock operations. Efforts to reduce animal-related injuries should include training farm youth about the many dangers presented by farm animals. In addition to educational efforts, structural modification of barns to limit animal interaction, isolation of dangerous animals, adequate supervision of youth, and wearing protective gear can all reduce the hazards associated with animals on the farm (Guyton et al., 2013; Hendricks and Adekoya, 2001).

Although ATVs may not be considered traditional farm machines, they have many uses on farms and often are a substitute for trucks, horses, tractors, or other machines. In 2014, 37% of household farm youth reported operating an ATV for work or recreation. Previous research has found that rider age, experience, and exposure, as well as ATV size, were the main contributors to risk of ATV injury (Denning et al., 2014; Levenson, 2003). Although many states have enacted regulations for youth ATV use, their effectiveness in reducing injuries is unclear. Widespread use of known effective safety measures, including prohibiting children less than 16 years of age from riding adult-sized ATVs, always wearing a helmet while riding, not riding on paved roads, and not riding as or carrying a passenger, could reduce ATV-related injuries among farm youth (Weichelt 2020; Shults et al., 2013).

One of the values of ongoing surveillance efforts is the ability to provide trend analyses over an extended time period. Although it is apparent that the overall injury rates have significantly declined over the study period for most household farm youth populations, the inclusion of quadratic trend modeling allows researchers to illustrate that the trends for some populations may be fluctuating. The quadratic trend for injuries to all household youth, working household youth, youth between the ages of 10 and 15, particularly males in this age group, and to a lesser extent females, demonstrates that injury rates, which decreased in the 2001 through 2009 CAIS surveys, may be increasing again.

Limitations

Although the CAIS data provide exposure information for household and hired youth, a major limitation of this study is the lack of exposure data for visiting youth. Although respondents were asked to provide the overall number of visiting youth and identify those who performed unpaid work on the farm, there was no indication of what other activities these youth may have participated in while visiting. In addition, like other exposure questions found in the CAIS, no data are available regarding the extent and duration of exposure that relatives and others who visited the farm experienced. Injury rates that do not consider exposure are likely to underestimate the risks associated with specific farming hazards. The collaboration with the USDA that permitted access to these data also prohibited the disclosure of unstable estimates. Estimates were considered unstable if they were based on a small number of cases or had a relative standard error greater than 35%. This restriction limited the amount of data that could be provided, particularly for hired youth injuries.

The CAIS data are also subject to recall and response bias due to the time lapse between injury events and survey administration (3 to 15 months) and the fact that, in most cases, the injured party was not the respondent. To reduce the impact of recall bias, the

respondents were asked to recall the most recent severe injuries that incurred on the farm, as research has shown that recall bias is not as strong for more severe events (Harel et al., 1994). Regarding response bias, an assumption was made that the female head of household would be the person in the household most likely to be knowledgeable regarding all injuries occurring to youth on the farm. However, there was no way to verify the accuracy of the responses given in the survey.

Additionally, because the design of the survey did not allow a second contact with farm operators who refused participation, there is the possibility of non-response bias. This limitation did not allow a follow-back questionnaire to assess non-respondents. However, the demographic characteristics of the respondents' farms were found to be similar to those reported for farms in the 2012 Census of Agriculture. This similarity between the survey estimates and the 2012 Census of Agriculture data suggests that the survey respondents were representative of farm operators across the U.S. and that any non-response bias in the survey could be expected to be minimal.

A final limitation of the study is that researchers had only six data points over the 14-year study period. The availability of additional data points would have allowed more precise estimates of trends, particularly when analyzing nonlinear trends.

Conclusions

Farms continue to be hazardous environments for youth. Although injuries have declined over the past decades, researchers should continue to monitor areas that have consistently been of concern, including injuries to youth between the ages of 10 and 15, work-related injuries, and animal-related injuries. Additionally, the recent overall increase in injury rates for household youth is worrisome. Additional research is needed on identified vulnerable populations and on assessment of non-working injuries to youth on farms.

The discontinuation of the CAIS program leaves a research gap for national data related to youth on farms and for ongoing detection and monitoring of areas of concern. The ongoing and future efforts of other agencies to fill this gap are essential to (1) focus injury prevention research, (2) target injury prevention messaging, and (3) assess if the observed increases in injury rates continue to be a significant trend.

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