

# Fatal On–Farm Injuries Among Youth 16 to 19 Years of Age: 1982–1994

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## Abstract

Data from the Vital Statistics Mortality (VSM) public use file and the National Traumatic Occupational Fatalities (NTOF) surveillance systems were used to describe fatal injuries among youth 16–19 years of age in the United States that occurred on farms for the years 1982 through 1994. The VSM captures all deaths in the United States, while the NTOF only captures occupational injury deaths. There were 550 total on–farm fatalities to youth 16–19 years of age in the VSM, and 221 occupational on–farm deaths from the NTOF for the same age group. These numbers suggest that 40% of the on–farm deaths were occupational. It was found that the proportions of deaths attributable to work increased with age. Fatality rates for on–farm nonoccupational deaths decreased slightly during the time period (from 8.4 deaths/100,000 for 1982–1985 to 6.8 deaths/100,000 for 1991–1994), while on–farm occupational fatality rates dropped dramatically (12.0 deaths/100,000 for 1982–1985 down to 4.9 deaths/100,000 for 1991–1994). The leading causes of death for on–farm occupational fatalities were machinery (54%) and electrical current (20%). The most common causes of on–farm fatalities that were nonoccupational were drowning (38.9%) and firearms (28.6%). For the years 1991 through 1994, drowning and firearms accounted for approximately the same number of on–farm deaths as machinery. Nonoccupational risks are a concern for youth 16–19 years of age on the farm.

**Keywords.** Farm, Youth, Fatal injuries.

**T**he hazards of the farm for youth have been well documented (Rivara, 1997; Stallones, 1989; Tormoehlen, 1986; Rivara, 1985). In 1998, there were approximately 363,000 youth 16–19 years of age who lived on farms, and an estimated 273,000 youth 16–19 years of age who worked on farms but were not part of the farm household (NIOSH, 1999). This large population of youth is exposed to hazards such as farm machinery, firearms, drowning, farm animals, and falls.

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Rivara (1997) reported an average of about 100 on-farm fatalities per year for youth less than 20 years of age between 1991 and 1993. These data showed that youth 15–19 years of age accounted for 34% of these on-farm deaths. However, Rivara did not address the relative importance of occupational and nonoccupational causes of death in the interpretation of his results. While data on work-related fatalities for youth associated with the agriculture industry, which includes agricultural services, forestry, and fishing operations, has been published (Derstine, 1996; Castillo et al., 1994), these studies did not address how many deaths occurred on farms. More recent work on deaths to youth working in the agricultural production and agricultural services industry did not specifically address on-farm deaths (Castillo et al., 1999).

To better understand the impact of occupational and nonoccupational deaths to youth that occur on farms, this study compared the causes of on-farm occupational fatal injuries for youth 16–19 years of age to all on-farm deaths reported for the same age group, estimated the proportion of on-farm deaths to youth 16–19 years of age that are likely to be nonoccupational, and examined changes in the rates of occupational and nonoccupational injuries over time.

## Methods

Two different national mortality surveillance systems were analyzed in this study: the National Center for Health Statistics (NCHS) Vital Statistics Mortality (VSM) public use data file and the National Institute for Occupational Safety and Health (NIOSH) National Traumatic Occupational Fatalities (NTOF) surveillance system.

The VSM was used to assess the total number of on-farm deaths occurring in the United States between 1982 and 1994 (NCHS, 1999). The VSM includes decedent demographics, geographic data, and location of death, but contains no narrative data about the death, or information to determine the work-relatedness of a death. Deaths to youth 16–19 years that occurred on farms, including farm buildings and land under cultivation, were selected for ICD-9 external cause of death codes (E-codes) E850 through E869 and E880 through E928. Case selection was limited to this E-code range because “location of injury” is only provided for these specific E-codes under ICD-9 coding rules. This narrow range of E-codes results in not including deaths associated with transportation-related E-codes (E810 through E848).

Deaths that occurred in farmhouses or the home premises of the farm were not captured using the VSM because these deaths are coded with a location code of “home.” Previous work has suggested that this may result in an undercount of 23% in the VSM for the total number of on-farm deaths (Stallones, 1989).

Fatality data for work-related deaths were obtained from the NTOF surveillance system (Jenkins et al., 1993). NTOF uses the original death certificate issued by a state and does not reflect any corrections or amendments made by a state on the death certificate following its submission to NIOSH. Deaths are included in the NTOF if the victim: was 16 years of age and older, died of an external cause of death (ICD-9 E800 through E999), and had a positive response to the “injury at work” box on the death certificate. To correspond to the VSM file, NTOF cases were selected if the location of death was marked as farm, and for the E-code ranges of E850 through E869 and E880 through E928.

The identification of cases in the NTOF depends on whether work-relatedness of the death was recorded on the death certificate. This has been shown to be problematic for youth working on farms (Murphy and Yoder, 1998). Previous work has shown that

death certificates identified approximately 80% of all work-related fatalities (Stout and Bell, 1991; Russell and Conroy, 1991; Drudi, 1998). To assess the relative ascertainment of the NTOF system for occupational on-farm deaths to 16- to 19-year-olds, the number of on-farm NTOF deaths for this age group during years 1992 through 1994 were compared to the number of on-farm deaths identified in the Bureau of Labor Statistics (BLS) Census of Fatal Occupational Injuries (CFOI) for the same ages and years. The CFOI is a multi-source occupational fatality system that provides a more accurate count of occupational deaths in the United States, but it has only existed since 1992 (Drudi, 1998). CFOI provided a benchmark for assessing the likely number of occupational deaths not identified in the NTOF.

Because of restrictions placed on the use of the VSM, it was not possible to do a case-by-case match of the VSM and NTOF data sets. Therefore, only counts from the two data sources were compared. The number of nonoccupational cases was estimated by subtracting the NTOF counts from the VSM counts within specific E-codes. While matching may have provided some minor benefits to this study, it is unlikely that matching would dramatically impact the results of the analysis.

To assess changes in causes of death for this age group over time, counts of deaths and fatality rates, by E-code categories, were examined for three time periods: 1982 through 1985, 1986 through 1990, and 1991 through 1994. For occupational fatality rate calculations, it was assumed that all work-related deaths that occurred on a farm were agricultural production deaths. For nonoccupational deaths, it was assumed that all occurred to farm residents.

Denominator estimates for workers 16 to 19 years of age for production agriculture were obtained from the Bureau of Labor Statistics (BLS), Current Population Survey (CPS) public-use data tapes (Department of Labor, 1992). For this study, it was assumed that all on-farm occupational deaths to youth 16 to 19 years of age occurred in the agricultural production industry. This ignores those youth who are employed in other industries (e.g., construction, agricultural services) who died on a farm while working. Because of this, the on-farm occupational fatality rates are likely overstated in this study.

Estimates of the number of farm residents 16-19 years of age were adapted from a series of Bureau of the Census publications on farm residents from the CPS (Banks and Mills, 1983; Banks and Mills, 1984; Department of Commerce, 1985; Department of Commerce, 1986; Department of Commerce, 1987; Department of Commerce, 1988; Department of Commerce, 1989; LeClere and Dahmann, 1990; Dahmann and Dacquel, 1992; Dahmann and Dacquel, 1993). Data in these publications were for two age ranges: 14 to 19 years of age, and 15 to 19 years of age. To approximate the number of 16- to 19-year-olds residing on farms, it was assumed that the number of youth was roughly equal for each specific age. Thus, youth farm residency estimates for 14- to 19-year-olds were reduced by 33.3%, while youth farm residency estimates for 15- to 19-year-olds were reduced by 20%. Information on farm residents was not available for 1992 through 1994, so it was assumed that the youth population for 1991 remained constant up to 1994. The use of farm resident numbers as the denominator for non-work fatalities assumes that all nonoccupational on-farm deaths to these youth occurred to farm residents only. This does not account for youth who visit farms, or youth who accompany parents working on farms. Because of this, these nonoccupational rates are likely overstated.

To address the issue of possible undercounts in the NTOF for occupational deaths occurring on farms, a sensitivity analysis was performed. NTOF counts were increased by 20%, 30%, and 40% in each of the three time periods. Occupational and

nonoccupational fatality rates were then re-calculated to reflect these changes in the number of occupational fatalities.

## Results

Within the E-code ranges examined in this study, 550 on-farm deaths were identified in the VSM, and 221 work-related on-farm deaths were identified in the NTOF for youth 16–19 years of age during the years 1982 through 1994. These numbers suggest that 40% of on-farm deaths were work-related for this age group. This corresponds to an annual average of 42 deaths from all causes to 16- to 19-year-olds on farms, of which 17 are work-related (table 1).

The comparison of CFOI and NTOF, covering the years 1992 through 1994, found that there was a 21% undercount by the NTOF of all on-farm occupational deaths for 16- to 19-year-olds. Based on this estimated undercount, there would have been about 44 on-farm deaths between 1982 and 1994 that occurred to youth 16 to 19 years of age that were occupational in nature but were not identified as such on the death certificate. This would result in less than 4 work-related on-farm cases per year being missed in this particular age group.

The proportion of work-related deaths within all on-farm deaths increased with age, ranging from 23.6% for 16-year-olds to 51.3% for 19-year-olds (table 2). Although the total numbers of on-farm deaths reported among 16- and 18-year-olds were comparable, 18-year-olds accounted for more on-farm work-related deaths. Males represented 95.2% of youth fatally injured on farms and 97% of the on-farm work-related fatalities in this age group. Approximately 41% of the on-farm deaths to males were occupational. For females, about 20% of the on-farm deaths were work-related.

Table 3 shows the distributions of the leading causes of death for all on-farm deaths and on-farm work-related deaths. For all on-farm deaths, the leading causes were machinery (29.5%), drowning (23.8%), and firearms (17.5%). The leading

**Table 1. Distributions of overall (VSM) and work-related (NTOF) on-farm deaths for youth 16–19 years of age, by year: 1982–1994<sup>[a]</sup>.**

Year	Number of Deaths				% Work-Related Death
	VSM	(%)	NTOF	(%)	
1982	60	10.9	43	19.5	71.6
1983	74	13.5	24	10.9	32.4
1984	62	11.3	27	12.2	43.5
1985	63	11.5	27	12.2	42.9
1986	36	6.5	17	7.7	47.2
1987	35	6.4	12	5.4	34.3
1988	50	9.1	20	9.0	40.0
1989	29	5.3	8	3.6	27.6
1990	37	6.7	14	6.3	37.8
1991	25	4.5	5	2.3	20.0
1992	32	5.8	11	5.0	34.4
1993	24	4.4	7	3.2	29.2
1994	23	4.2	6	2.7	26.1
Total	550	100.0	221	100.0	40.2

<sup>[a]</sup> Selected E-code ranges E850–E869 and E880–E928.

**Table 2. Distributions of overall (VSM) and work-related (NTOF) on-farm deaths by age: 1982–1994<sup>[a]</sup>.**

Age	Number of Deaths				% Work-Related Death
	VSM	(%)	NTOF	(%)	
16	127	23.1	30	13.6	23.6
17	143	26.0	54	24.4	37.8
18	120	21.8	55	24.9	45.8
19	160	29.1	82	37.1	51.3
Total	550	100.0	221	100.0	40.2

<sup>[a]</sup> Selected E-code ranges E850–E869 and E880–E928.

causes of death for on-farm work-related fatalities were machinery (54.3%) and electric current (19.5%). By comparing these two surveillance systems within specific E-code categories, the proportion of cases which were attributable to work were: electric current (100%), lightning (100%), machinery (74%), struck by or against objects/struck by falling objects (56%), mechanical suffocation (46%), falls (43%), other injury by animals (38%), and poisoning (20%). There were 329 remaining fatalities on farms during this time period that were assumed to be nonoccupational. The leading causes of death for the nonoccupational farm fatalities were: drowning (38.9%), firearms (28.6%), and machinery (12.8%).

The industry of employment for these 16- to 19-year-olds was also examined based on the NTOF. One hundred and two deaths (46%) were in the agriculture/forestry/fishing industry division, with 37 deaths (16.7%) occurring in non-agricultural industries (e.g., construction, services). In 82 of the cases, the industry of employment could not be determined.

Each of the 5 leading causes of death identified in table 3 decreased in occurrence between 1982 and 1994 (table 4). Decreases in deaths due to machinery, drowning, electric current, and mechanical suffocation ranged from 57% to 92% between the time periods 1982 to 1985 and 1991 to 1994. Firearm-related deaths showed a less substantial decrease of only 25%. The ranking of causes of death also changed substantially between the initial and final 4-year time periods examined here. For the

**Table 3. Leading causes of death for overall (VSM) and work-related (NTOF) on-farm deaths for 16–19 years of age: 1982–1994.**

Cause of Deaths	Number of Deaths				% Work-Related Death
	VSM	(%)	NTOF	(%)	
All causes of death (E850–E869 and E880–E928)	550	100.0	221	100.0	40.2
Machinery (E919)	162	29.5	120	54.3	74.1
Drowning (E910)	131	23.8	3	1.4	2.3
Firearms (E922)	96	17.5	<3	<1.0	<3.0
Electric current (E925)	42	7.6	43	19.5	100.0
Mechanical suffocation (E911–E913)	22	4.0	10	4.5	45.5
Lightning (E907)	13	2.4	13	5.9	100.0
Struck by falling objects/struck against or struck by object (E916–E917)	16	2.9	9	4.0	56.3
Other injury by animals (E906)	8	1.5	3	1.4	37.5
Accidental poisoning (E850–E869)	15	2.7	3	1.4	20.0
Falls (E880–E888)	14	2.5	6	2.7	42.9
Fire and flames (E890–E899)	5	0.9	<3	<1.0	—
Excessive heat and cold (E900–E901)	9	1.6	<3	<1.0	—
Other (E918, E920, E921, E923, E928)	17	3.1	9	4.0	52.9

**Table 4. Causes of death for all on-farm deaths (VSM) for youth 16–19 years of age for three time periods: 1982–1985, 1986–1990, and 1991–1994.**

Cause of Deaths	No. of Deaths 1982–1985	No. of Deaths 1986–1990	No. of Deaths 1991–1994
All causes of death (E850–E869 and E880–E928)	259	187	104
Machinery (E919)	82	55	25
Drowning (E910)	60	45	26
Firearms (E922)	36	33	27
Electric current (E925)	23	17	<3
Mechanical suffocation (E911–E913)	12	9	<3
Lightning (E907)	6	6	<3
Struck by falling objects/struck against or struck by object (E916–E917)	7	5	4
Other injury by animals (E906)	4	<3	<3
Accidental poisoning (E850–E869)	11	<3	<3
Falls (E880–E888)	5	7	<3
Fire and flames (E890–E899)	<3	<3	3
Excessive heat and cold (E900–E901)	3	3	3
Other (E918, E920, E921, E923, E928)	9	<3	6

years 1982 to 1985, and to a lesser extent for the years 1986 to 1990, machinery-related deaths were clearly the leading cause of death to youth 16–19 years of age occurring on farms. However, between 1991 and 1994, unintentional firearm-related events, drowning, and machinery-related events were essentially equal in occurrence for this age group. In addition, electrocutions and mechanical suffocation decreased over the study period, down from 35 deaths between 1982 and 1985 to less than 3 deaths in the 1991 to 1994 time period.

Table 5 provides the fatality rates for nonoccupational and occupational on-farm deaths in the three defined time periods. These rates suggest that the primary decreases in risk to youth on farms have occurred among occupational injuries, falling from 12 deaths/100,000 workers during the period 1982 through 1985 to 4.9 deaths/100,000 workers for the period 1991 through 1994. The rate for nonoccupational deaths decreased between the first and last time periods, but not as dramatically (from 8.4 deaths/100,000 youth to 6.8 deaths/100,000 youth).

Table 6 provides the results of the sensitivity analysis for the likely undercount of occupational deaths by the NTOF surveillance system. The results suggest that the main impact of any undercounts of occupational deaths for this age group would have been most notable in the 1982 to 1985 time period. If NTOF has an undercount of approximately 20%, as suggested by the CFOI comparison provided earlier, then there would be little change in the overall conclusions provided in table 6: a large decrease in occupational fatality rates, a modest decrease in nonoccupational fatality rates, and nonoccupational fatality rates becoming slightly higher than occupational fatality rates in the final period of 1991 to 1994. If the NTOF undercount is 30%, then the decrease in occupational fatality rates would still be substantial, although occupational rates would remain higher than nonoccupational fatality rates for each time period. In addition, nonoccupational fatality rates would show little change between the three time periods. Finally, if the NTOF is assumed to have a 40% undercount, occupational fatality rates would still show dramatic decreases over the three time periods but would remain higher than nonoccupational rates in each time period. Nonoccupational fatality rates under this assumption would begin to show the possibility of increasing with time, or at a minimum, remaining unchanged.

**Table 5. Occupational and nonoccupational average annual deaths and fatality rates for three time periods: 1982–1985, 1986–1990, and 1991–1994.**

Years	Average Annual 16– to 19–Year– Old Farm Residents <sup>[a]</sup>	Average Annual Nonoc- cupational Deaths <sup>[b]</sup>	Average Annual Nonoc- cupational Fatality Rate <sup>[c]</sup>	Average Annual 16– to 19–Year– Old Farm Workers <sup>[d]</sup>	Average Annual Occupational Deaths <sup>[e]</sup>	Average Annual Occupational Fatality Rate <sup>[f]</sup>
1982–1985	409,800	34.5	8.4	252,500	30.3	12.0
1986–1990	322,900	23.2	7.2	173,300	14.2	8.2
1991–1994	276,800	18.8	6.8	148,600	7.3	4.9
Total	335,500	25.3	7.5	190,000	17.0	8.9

<sup>[a]</sup> Based on adjustment of farm resident numbers published by the Bureau of Census for youth 15 to 19 years of age (see Banks and Mills, 1983; Banks and Mills, 1984; Bureau of the Census, 1985; Bureau of the Census, 1986; Bureau of the Census, 1987; Bureau of the Census, 1988; Bureau of the Census, 1989; LeClere and Dahmann, 1990; Dahmann and Dacquel, 1992; Dahmann and Dacquel, 1993).

<sup>[b]</sup> Derived from the VSM after removing occupational deaths identified in the NTOF.

<sup>[c]</sup> Fatality rate expressed as deaths per 100,000 farm residents 16–19 years of age.

<sup>[d]</sup> Estimates derived from the 1982–1994 Current Population Survey public use data files.

<sup>[e]</sup> Derived from the NTOF.

<sup>[f]</sup> Fatality rate expressed as deaths per 100,000 farm workers 16–19 years of age.

**Table 6. Sensitivity<sup>[a]</sup> of occupational and nonoccupational fatality rates for youth 16 to 19 years of age to the under reporting of on–farm occupational deaths for three time periods: 1982–1985, 1986–1990, and 1991–1994.**

Years	20% Increase in Occupational Deaths Occurring on Farms		30% Increase in Occupational Deaths Occurring on Farms		40% Increase in Occupational Deaths Occurring on Farms	
	Average Annual Non- occupational Fatality Rate <sup>[b]</sup>	Average Annual Occupational Fatality Rate <sup>[c]</sup>	Average Annual Non- occupational Fatality Rate <sup>[b]</sup>	Average Annual Occupational Fatality Rate <sup>[c]</sup>	Average Annual Non- occupational Fatality Rate <sup>[b]</sup>	Average Annual Occupational Fatality Rate <sup>[c]</sup>
1982–1985	7.0	14.4	6.3	15.6	5.5	16.8
1986–1990	6.3	9.8	5.9	10.6	5.4	11.4
1991–1994	6.2	5.9	5.9	6.4	5.7	6.9

<sup>[a]</sup> Sensitivity was assessed by artificially increasing the number of occupational fatalities in the NTOF by differing amounts in each time period, and adjusting the nonoccupational counts down by the corresponding increase in occupational deaths.

<sup>[b]</sup> Deaths per 100,000 farm residents 16–19 years of age. Denominator based on adjustment of farm resident numbers published by the Bureau of Census for youth 15 to 19 years of age (see Banks and Mills, 1983; Banks and Mills, 1984; Bureau of the Census, 1985; Bureau of the Census, 1986; Bureau of the Census, 1987; Bureau of the Census, 1988; Bureau of the Census, 1989; LeClere and Dahmann, 1990; Dahmann and Dacquel, 1992; Dahmann and Dacquel, 1993).

<sup>[c]</sup> Deaths per 100,000 farm workers 16–19 years of age. Denominator derived from the 1982–1994 Current Population Survey public use data files.

## Discussion

On-farm fatalities decreased approximately 60% for youth 16 to 19 years of age between the two 4-year time periods of 1982 through 1985 and 1991 through 1994. On-farm work-related fatalities decreased by 76% between these two time periods, while nonoccupational fatalities appeared to decrease approximately 45%. These reductions in on-farm fatalities are consistent with reports on occupational fatalities for production agriculture in general, and with adolescent farm fatalities specifically (Myers and Hard, 1995; Rivara, 1997).

Rivara (1997) suggested that decreases in on-farm deaths were due in part to improved emergency response for rural areas, better medical care for trauma victims, and the increased use of safer farm machinery (e.g., tractors with Roll-Over Protective Structures). The results of this study suggest additional reasons for the decline in on-farm deaths for youth 16 to 19 years of age: 1) a substantial decrease in the number of youth living on and working on farms, and 2) a major decrease in the rate of work-related deaths to these youth on the farm.

The impact of the decreasing number of youth on farms has been dramatic. Table 5 shows that the average number of on-farm deaths between 1982 and 1985 was approximately 65 deaths per year. The farm resident population 16–19 years of age during this time period was about 410,000, while the number of youth 16–19 years of age working on farms was around 252,500. For the time period 1991 through 1994, the average number of farm deaths decreased to 26 deaths per year. However, the farm resident population 16–19 years of age dropped 32% to around 277,000 youth, while the farm employment in this age group dropped over 41% to about 149,000 workers (table 5). If the same number of youth 16–19 years of age were living or working on farms between 1991 and 1994 as there were in 1982 through 1985, the expected number of deaths on farms would have increased from 26 to nearly 40 deaths per year between 1991 and 1994. This would have resulted in an on-farm fatality reduction of only 38%, rather than the actual 60% reduction reported here .

A decrease in the number of work-related deaths as the second major contributor to the reduction of on-farm deaths can be seen directly in the 60% reduction in work-related fatality rates for workers 16–19 years of age (table 5), with table 6 providing supporting evidence that this decrease is a real phenomenon. An explanation for this decrease is suggested by the types of E-codes that have shown the largest decreases between 1982 and 1994 (table 4). Machinery deaths and electrocutions, which are highly associated with work (table 3), decreased 70% and 92%, respectively, between the 1982 to 1985 and 1991 to 1994 time periods (table 4). Their decrease accounts for much of the drop in occupational fatality rates occurring on farms reported in table 5. Similar decreases in these two causes of on-farm death for youth 15 to 19 years of age were also evident in a comparison of the results from two papers by Rivara (1985; 1997).

The reasons for the decrease in work-related deaths on farms for youth 16–19 years of age may be related to several factors occurring in the production agriculture industry during the 1980s. As suggested by Rivara (1997) and Myers and Hard (1995), safety improvements in farm machinery increased dramatically in the 1980s, including an increase in the use of tractors with Roll-Over Protective Structures (Myers and Snyder, 1995). Myers and Hard (1995) also suggested that child labor laws requiring the training of youth 14 to 15 years of age before allowing them to operate tractors and machinery on farms not owned by their family may have had an

impact on the safer operations of such machinery by youth working on farms. The real impact of such training programs has not been evaluated.

Explanations for the decreases in the number of electrocutions are not readily apparent, although occupational electrocutions for all workers have been shown to have decreased between 1980 and 1995 (CDC, 1999). A major cause of electrocutions to youth was contacting overhead power lines with conductive objects such as grain augers, irrigation pipe, or other farm implements (Helgerson and Milham, 1985; NIOSH, 1986). Educational campaigns to address the risks of contacting overhead power lines were conducted in the 1980s by NIOSH, electrical power companies, and extension safety specialists, although the impact of these activities was never evaluated. Increased use of underground power lines around farm buildings may be a second factor contributing to the reduction of such electrocutions, although no information is available on whether this or other changes to the farm environment explain these decreasing electrocution deaths.

These results suggest that nonoccupational causes of death are accounting for an increasing proportion of the mortality for youth 16 to 19 years of age on farms, even after accounting for likely undercounts of occupational deaths to these youth. Drowning and firearm deaths, which were almost exclusively nonoccupational in nature, accounted for 37% of all on-farm deaths for these youth between 1982 and 1985. By 1991 through 1994, however, drowning and firearms accounted for over half of the deaths among these youth. While the number of deaths from these two events decreased over this 13-year time period, neither decreased to the extent that the leading causes of occupational death had. The number of unintentional firearm deaths, in particular, appears to have changed little.

Several studies have identified adolescents and young adults to be among those at highest risk for drowning (Howland et al., 1996; Warneke and Cooper, 1994; Baker et al., 1992; CDC, 1992a; Patetta and Biddinger, 1988; Wintemute et al., 1987; CDC, 1985). Drowning as a concern for youth on farms has also been reported (Rivara, 1997; Stallones, 1989; Tormoehlen, 1986; Rivera, 1985). A major risk factor suggested for drowning among adolescents is alcohol use at the time of drowning (Howland and Hingson, 1988; Patetta and Biddinger, 1988; Wintemute et al., 1987; CDC, 1986). Other possible risk factors include swimming or being around natural bodies of water such as ponds, streams, and lakes (Warneke and Cooper, 1994; CDC, 1992a; Patetta and Biddinger, 1988; Wintemute et al., 1987; CDC, 1986), being alone around bodies of water (Patetta and Biddinger, 1988), and the lack of a person trained in CPR and other lifesaving techniques at the site of the drowning (Patetta and Biddinger, 1988; Wintemute et al., 1987). In addition, adolescent males, who have been found to be at highest risk for drowning, tend to engage in these high-risk types of behaviors more than other groups (CDC, 1993; Howland and Hingson, 1988).

Unintentional firearm deaths are also most common among youth 15 to 19 years of age (CDC, 1992b; Morrow and Hudson, 1986), and youth living in rural areas are at higher risk than youth in urban areas (CDC, 1992b). A major activity associated with unintentional firearm deaths for adolescents is hunting (Cole and Patetta, 1988; Morrow and Hudson, 1986). Possible risk factors for hunting-related deaths include not wearing blaze orange hunting gear (CDC, 1996), allowing adolescents to hunt unsupervised, and low levels of hunter safety training for adolescents (Cole and Patetta, 1988). Other common events associated with unintentional firearm deaths include target practicing with guns, improper loading or unloading of guns, playing with guns, and cleaning guns (Morrow and Hudson, 1986). It is likely that most, if not all, of these possible risk factors identified for drowning or unintentional firearm deaths for adolescents are common in the farm environment. These risk factors

provide a starting point for identifying appropriate actions for farm families to consider in addressing nonoccupational fatality hazards on their farms.

In conclusion, these data indicate that there is still a need to continue improving the safety of youth working on the farm, but they also indicate that research into nonoccupational injuries should be increased. This nonoccupational research should include studies to:

- Determine the role of previously identified risk factors on farm-related deaths to these youth
- Determine any additional risk factors that may exist that are unique to the farming environment
- Evaluate the effectiveness of educational or other intervention programs designed to prevent injury deaths to youth exposed to farm hazards.

In addition, more research is needed to examine the relationship between occupational and nonoccupational on-farm deaths for youth less than 16 years of age, which were not included in this study.

Finally, as with most studies, several limitations are identified in this study. These include the lack of information on on-farm deaths occurring in farm homes, the limited E-code range examined in this study, the inability to examine youth below 16 years of age, and the problematic use of denominator data that is not a perfect match to the fatality data. Despite the limitations of this study, the patterns and relative comparisons between the numbers and rates presented in this study should be considered a realistic view of changes in on-farm deaths for these youth during the study period. The majority of the limitations in this study should be expected to be consistent between the three time periods examined in the study, and as such, would not impact the overall conclusions.

## References

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