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Occupational and Nonoccupational Farm Fatalities Among Youth for 2000 Through 2012 in Pennsylvania

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ABSTRACT. Agriculture is one of the most hazardous industries in the United States. It is crucial to analyze the previously collected farm fatality data in Pennsylvania involving youth to identify fatality sources and to delineate prevention strategies to mitigate future occurrences. The Penn State Farm and Agricultural Injury Database was updated to include the Occupational Injury and Illness Classification System (OIICS) for source and event or exposure. Occupational and nonoccupational incidents were compared based on age groups, religious sect, source of injury, and the injury event or exposure. A total of 82 fatalities to youth under 20 years were identified. Youth under 5 years old had the highest fatality rate of 87.1 fatalities per 100,000 farm household youth per year. The percentages of occupational and nonoccupational fatalities were 30.5% and 62.2%, respectively. Three primary sources accounted for 76% of the 82 farm fatalities: vehicles, machinery, and structures and surfaces. The majority of fatally injured youth (78%) were Anabaptist. The Anabaptist youth were 7 times more likely to be involved in occupational incidents than the non-Anabaptist youth. Youth <10 years of age who were not alone at the time of the fatal incident accounted for about half of the deaths, indicating the peril of adults attempting to supervise youth in the workplace. This fatal injury analysis to youth has identified common fatality injury patterns and risk factors to youth. The data can be used to identify intervention strategies for youth and underserved populations (Anabaptists) and can be used to help motivate adults and parents to adopt safety practices to prevent future injury occurrences. This paper also helps to illustrate the value of state-based monitoring of farm injury to youth using methods available to many states and territories.

KEYWORDS. Amish, Anabaptist, fatality, safety, youth

INTRODUCTION AND BACKGROUND

Agriculture is not only the most hazardous industry in the United States but also one of the three most hazardous industries in the world (the others being mining and construction).[1,2] Agriculture employs 1 billion workers worldwide, or more than a third of the world's labor force, and accounts for approximately 70% of child labor worldwide.[1] According to the International Labour Organization, the most vulnerable groups are found in family subsistence agriculture, in plantations as daily paid laborers, seasonal or migrant workers without land, and most importantly child laborers.[1]

In the United States, more than 100 youth under the age of 20 die on farms each year and over 16,000 farm-related injuries occur.[3] The

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number of children living on farms and ranches in the United States is 1.1 million, and more than half of them work on the farm or ranch.[4] About every 3 days a child dies in an agriculture-related incident, and everyday 45 children are injured on farms or ranch in the United States. Machinery, motor vehicles, and drowning are the major sources of fatal injuries.[4]

In a review of US death certificate data for the 6 years from 1995 to 2000, 695 farm-related youth fatalities were identified, with an average annual rate of 9.3 fatalities per 100,000 youth.[5] The highest annual fatality rate by age was for 16- to 19-year-olds (10.4 per 100,000 youth), closely followed by youth under 10 years of age (10.1 per 100,000 youth).[5] An analysis of the Census of Fatal Occupational Injury (CFOI) for the years 1992 through 2002 identified 310 work-related deaths to youth under 20 years of age in the agricultural production sector (crops and livestock).[6] The fatal work-related injury rate was 3.6 times higher than that for young workers in all industries and 2.9 times higher than that of adult workers in all industries combined. Fatality rates for young workers in all industries decreased during the 1997–2002 period, whereas fatality rates for young workers in agriculture increased.[6]

Anabaptist religious groups immigrated to North America in the 18th and 19th centuries from Europe and clustered into four major groups: Amish, Brethren, Hutterites, and Mennonites.[7] In the United States, the current estimated Amish population is 281,675. Between 2008 and 2013, the Amish population has expanded 15% in Pennsylvania and 20% nationwide.[8] These numbers include all Amish groups (Old Order and New Order) that use horse-and-buggy transportation, but exclude car-driving groups such as the Beachy Amish and Amish Mennonites. Ohio and Pennsylvania rank first and second in the highest population of Amish people, with estimated 65,475 and 65,270 people in 2013, respectively.[9] The Amish population constituted 0.6% and 0.5% of Ohio's and Pennsylvania's population in 2013, respectively.[i,10]

Anabaptist groups live in small-scale family farming operations.[7] Anabaptist children are exposed to unique farming hazards because of their unique lifestyle:

1. Amish and Old Order Mennonite families use horse-and-buggy transportation, placing children at increased risk if horses are frightened: children are also at risk when they travel on public roads with motor vehicles.[7]
2. Anabaptist people predominantly use animals to pull their farm equipment. Yet they may selectively operate their equipment and machinery by using diesel engines to operate pumps, and compressed air (pneumatic) and oil (hydraulic) for power.[11]
3. A typical Anabaptist family has six to eight children. Those children begin working and are exposed to the existing farm hazards at a young age.[12] The farmstead is their playground.[13]
4. Anabaptists believe that work is essential. When somebody is working the soil, they are as close to God as they can get.[13] Children are viewed as "gifts of God" and families spend considerable time teaching their values, rules, and proper work methods.[14] They want their children to be safe and protected from harm.[14] Children perform farms chores such as bottle-feeding calves, collecting eggs, and weeding garden as young as 3 to 5, and between ages 10 and 12 they are given chores that involve power equipment.[15] However, working at a very young age puts the children at more risk of the same hazards than their parents due to developmental factors and experience.[12]

According to a study by Purdue University, the Old Order Anabaptist communities have higher-than-expected numbers of farming injuries.[16] Falls were the most common cause of injury, exposure to animal contact was another common cause, and many injuries resulted in broken bones.[16]

In the United States, there is no comprehensive national database of childhood farm injuries, fatalities, or hospitalizations.[4] Penn State has consistently collected state-level farm-

and agriculture-related fatal injury data since 1980. There are 355 cases in the database for the years 2000 through 2012, with 82 cases identified as youth aged 19 and under. There are very limited research data involving fatal farm- and agriculture-related injury to youth in Pennsylvania. Unique contributions to the literature in this analysis are (a) the use of the Occupational Injury and Illness Classification System (OIICS) categories to identify the primary injury source and event or exposure code; (b) the use of FAIC (Farm and Agricultural Injury Classification) code to determine whether the fatality was occupationally related; (c) comparison of fatal incident cases between the Anabaptist religious sect and non-Anabaptists; and (d) the examination of the relationships between characteristics of the fatalities and age, gender, and religious sect.

The objectives of this study were to analyze an existing injury database to identify:

1. Characteristics of farm- and agriculturally related youth fatalities in terms of age at death, gender, religious sect, occupational classification, and primary injury source.
2. Change in prevalence of occupational and nonoccupational injuries of youth over time.
3. Trends over time involving injury sources.

METHODS

Data sources of potential cases included death certificates from the Pennsylvania Department of Health's Office of Vital Statistics, police and coroner investigative reports, a newspaper and media clipping service, and reports of farm-related injury incidents by county agricultural and extension educators and rural volunteer emergency medical service (EMS) providers. Multiple sources of information to clarify details of potential cases were used for each case before it was entered into the database. Penn State's Institutional Review Board (IRB) and the Pennsylvania Department of Health approved the procedures for collecting and storing the injury data.

The same sources identified above were also used to identify whether or not the victim had an association with an Anabaptist religious sect. Indications of this association included statements in newspaper, media and investigative reports, places of burial, and follow-up contact with local extension educators.

In order to calculate age-specific fatality rates, farm household youth population estimates obtained from the National Institute for Occupational Safety and Health (NIOSH) 2012 Childhood Agricultural Injury Survey (CAIS) were used.[17] The criteria for a "farm" that have agricultural sales of $1,000 or more was used to estimate the number of household youth less than 20 years of age on PA farms.[17] This estimate does not include youth working but not living on the farm or youth visiting farms.

All data were coded according to the US Department of Labor's Bureau of Labor Statistic's Occupational Injury and Illness Classification System (OIICS) version 2.01 and the American Society of Agricultural and Biological Engineer's Farm and Agricultural Injury Classification (FAIC) code (ASABE Standard S572.1).[18] Based on the incident description, OIICS allowed us to classify the cases by the associated event or exposure and the source of injury. The FAIC code ensured consistency in coding injury incidents related to farms and agriculture.[18]

The FAIC Code was adopted by the American Society of Agricultural Engineers (ASAE) Ergonomics, Safety, and Health Committee in 1998. Its purpose is to facilitate consistent and accurate classification of farm- and agriculture-related fatalities and injuries. FAIC code is a classification system that

- parallels, to the extent appropriate, current nationally established methods for classifying and assigning work-related injury cases to an industry;
- provides a systematic scheme for separating farm production work cases from nonfarm and non–farm production work cases; and
- allows for identification of cases that reflect unique situational exposures prevalent in the agricultural industry, for example, children in work environments.

FAIC code categories are assigned as (1) occupational (farming/farm production work: FAIC-01 through FAIC-04) or (2) nonoccupational (nonfarm production work/farm lifestyle: FAIC-05 through FAIC-09) fatalities associated with farms and agriculture.[19] These categories are explained in Appendix A.

The Statistical Package for the Social Sciences (SPSS) for Windows was used to analyze the 2000–2012 PA database of agricultural fatalities.[20] Univariate statistics (i.e., frequency distributions) were used to describe the characteristics of child fatalities. The relationships among variables measuring the characteristics of child agricultural fatalities were examined using contingency tables, *t* tests, correlational analyses, and logistic regression.

RESULTS

Demographics

This study used data from the Penn State database of farm- and agriculture-related fatalities over the time period of 2000–2012. Analyses were restricted to fatalities among youth under 20 years of age. There were 82 cases in the database meeting these criteria. Generally, the demographic characteristics of these fatalities were consistent with research findings from other independent sources with age, gender, and religious sect being common themes (Table 1).[5]

Boys were 4.5 times more likely to be involved in a farm- and agriculture-related fatality than girls, with 80.5% of the youth fatalities being male and 19.5% being female (Table 1).

The largest proportion of farm- and agriculture-related fatalities was among the youngest victims: about one half (49%) of the youth fatalities occurred among children aged 0 to 4 years. Most of the female victims (62.5%, 10 out of 16) were in the youngest age group (<5 years; data not shown).

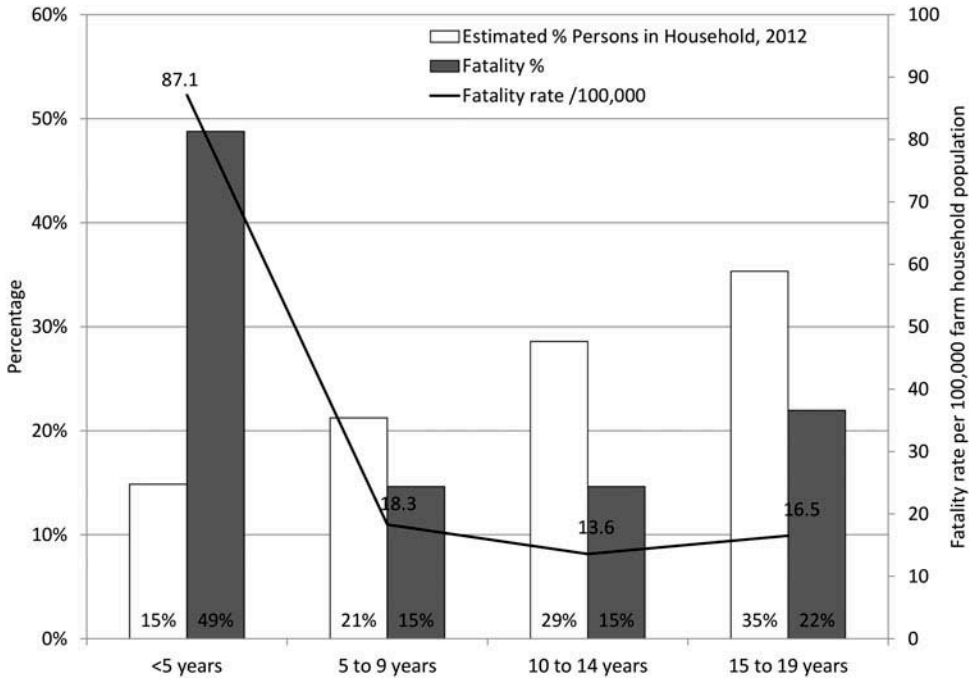
The majority of youth involved in a farm- and agriculture-related fatality were Anabaptist (78%). Moreover, Anabaptist youth involved in a farm- and agriculture-related fatality were significantly younger than non-Anabaptist youth ($t = 2.362$; $df = 80$; $P = .021$). On average, Anabaptist youth were 6.9 years old when they died, whereas non-Anabaptist youth were 10.8 years old. Further examination indicates that the age differentials between Anabaptist and non-Anabaptist youth involved in a farm- and agriculture-related fatality were greatest among the very youngest and the very oldest youth. About 53% of Anabaptists were under 5 years old when they died, compared with 33% of non-Anabaptists in this age group. On the other end of the age spectrum, 16% of Anabaptist youth were 15 to 19 years old when they died, compared with 44% of non-Anabaptist youth. Twenty percent of the Anabaptist youth were female (13 of 64) and almost 70% of the Anabaptist females were under 5 years old at the time of incident. There were only three female victims who were non-Anabaptist.

Fatality rate calculations were derived using information from the NIOSH 2012 Childhood Agricultural Injury Survey (CAIS), which provided farm household youth population estimate for PA youth under the age of 20 in 2012 ($N = 23{,}768$).[17] These data are used

TABLE 1. Fatalities by Gender, Age Group, and Religious Sect in Pennsylvania: 2000–2013 ($N = 82$)

Youth characteristic	Anabaptist	Non-Anabaptist	Number of fatalities	Percentage (%)
Gender				
Female	13	3	16	19.5
Male	51	15	66	80.5
Age at death				
<5 years	34	6	40	48.8
5–9 years	10	2	12	14.6
10–14 years	10	2	12	14.6
15–19 years	10	8	18	22.0

FIGURE 1. Average fatality rate, fatality, and estimated household percentage by age group for youth under 20 years of age in PA.



to approximate youth population percentages, fatality percentages, and fatality rates per 100,000 farm household residents by age group in Figure 1. Most notably, the percentage of farm household residents under 5 years old was 15%, whereas the percent fatalities in this age group was 49%. When considering fatalities per 100,000 farm household residents, the highest fatality rate was for youth under 5 years of age (87.1 average annual fatalities per 100,000 youth). The fatality rate for youth 5–9, 10–14, and 15–19 years of age were 18.3, 13.6, and 16.5 per 100,000 youth, respectively. The average fatality rate for youth under 20 years of age in Pennsylvania was 26.5 fatalities per 100,000 farm household youth per year during 2000 through 2012 (Figure 1).

FAIC Codes Associated With Youth Fatalities

Fatalities were classified as occupational (30.5%) and nonoccupational (62.2%). Six fatalities were not categorized by FAIC code because of a lack of information, although all provided information indicated that they were farm and agriculturally related.

Twenty-five fatalities (30.5%) were occupational. All of the occupationally related deaths during the 2000–2012 period were associated with the occupation of farming (Farm Production Work, FAIC-01). The highest number of occupational fatalities occurred among Anabaptist youth aged 15–19 years (8 out of 25 occupational fatalities; 32%), followed closely by Anabaptist youth aged 10–14 years (7 out of 25 fatalities; 28%) and 5–9 years (6 out of 25 fatalities; 24%).

When the fatality was classified as nonoccupational ($n = 51$), it was seen that the majority of nonoccupational fatalities (31 cases, 61% of nonoccupational cases) occurred from exposure to farm equipment, tools, and product hazards (FAIC-06). Common incidents in this type (FAIC-06) might involve falling from a tractor or machinery while being carried as an extra rider and runovers by a tractor or farm machinery. Fifteen (FAIC-07) nonoccupational fatalities were related to farm structures and landscapes, for example, barns and ponds

(drowning in farm pond, suffocation in feed bin, falling into manure pit, etc.). The remaining fatalities were categorized as: 2 animal-related incidents (FAIC-08), 2 roadway traffic incidents (FAIC-09), and 1 farm services incident (FAIC-05).

About three fourths of youth who were involved in nonoccupational activities were less than 5 years old (39 out of 51 fatalities; 76%). Moreover, the highest number of nonoccupational fatalities occurred among Anabaptist children <5 years (33 out of 51 fatalities; 65%), with these being primarily FAIC-06 (nonworker exposure to equipment, tools, objects, and products).

Deaths were further analyzed regarding the relationship between whether a youth fatality was occupational and each of the following factors: gender, change in prevalence of occupational fatalities over time, primary source of fatality, and event or exposure leading to fatality. Youth for whom the FAIC code was undetermined; also, children under 5 years were excluded from these analyses because there was no occupational incident for this age group, resulting in a sample size of $n = 37$.

Among these 37 fatalities, 89% were males. There was a statistically significant relationship between gender and whether the fatality was an occupational fatality (Pearson chi-square = 9.343; $df = 1$; $P = .002$): 76% of the males were involved in an occupational activity, whereas none (0%) of the females were. However, caution should be used when interpreting these results due to the small number of females in the analysis ($n = 4$).

The rate at which occupational and nonoccupational fatalities occurred among youth aged 5 to 19 in Pennsylvania did not appear to vary by year (Pearson $r = -.174$; $P = .302$). This means that the prevalence of occupational youth fatalities in Pennsylvania between 2000 and 2012 did not change significantly during that time period.

The relationship between age and religious sect (Anabaptist or non-Anabaptist), and whether a fatality was occupational was examined using logistic regression and odds ratios (ORs). ORs is an analysis technique used to estimate the risk of the event occurring relative to the risk of the event not occurring, with the odds being a ratio of the two probabilities.[21] Because there were no occupational fatalities among children under 5 years, this age group was also excluded from the calculations, resulting in 37 cases for the analysis. The analysis indicated that there was no association between age and whether the fatality was occupational (logistic regression coefficient = −.070; OR = 0.932; $P = .439$) for youth aged 5 to 19, controlling for whether the youth was Anabaptist. However, Anabaptist youth were significantly more likely than non-Anabaptists to be involved in an occupational fatality (logistic regression coefficient = 1.995; OR = 7.350; $P = .013$). This result indicates that the odds of being involved in an occupational fatality are 7.35 times greater for Anabaptist youth than non-Anabaptist youth, controlling for age.

Primary Source of Fatality

Each of the 82 fatalities was classified for source of injury using the Occupational Injury and Illness Classification System. By definition, the source identifies the objects, substances, equipment, and other factors that were responsible for the injury.[22] The three primary sources accounting for 76% of the farm- and agriculture-related fatalities were (a) machinery (24.4%), (b) structures and surfaces (17.1%), and (c) vehicles (34.1%). The remaining types of primary sources were combined for further statistical analysis as "other" (33%).

(a) Machinery ($n = 20$). Thirteen of the 20 (65%) machine-related cases involved agricultural and garden machinery (balers, combines, feed grinders, harvesting machinery, plowing, planting and fertilizing machinery, and spreading machinery). Another six cases (30%) involved construction, logging, and mining machinery (front-end loaders, skid steers, and excavation machinery), and one case involved aerial lift (material and handling machinery).

(b) Structures and surfaces ($n = 14$). Cases in this classification included 5 farm pools, 3 confined spaces (manure pits), 2 existing floor openings, 2 fences and gates, 1 ceilings and walls, and 1 barn.

(c) Vehicles ($n = 28$). Thirteen of 28 vehicle-related fatalities involved off-road and industrial vehicles including farm tractors, power take-offs (PTOs) (10), forklift, order picker, platform truck-powered (2), and an all-terrain vehicle (ATV). Seven cases (25%) involved motorized highway vehicles including an automobile, a motorcycle, a sports utility vehicle (SUV), and three trucks (three victims were Anabaptist: hit by an automobile on roadway, run over by farm truck, crushed under a truck). Animal- and human-powered vehicles, for example, a horse-drawn buggy, were the source of incidents in seven cases (all Anabaptist).

(d) Others ($n = 20$). Other fatality sources identified animals, bales, containers, chemicals, water, steam, lightning, and building materials.

The secondary source is defined as "the object, substance, or person that generated the source or contributed to the event or exposure."[22] A secondary source was identifiable for 45% (37 of 82) of all incidents. Among those incidents with a secondary source, the distribution was 41% structures and surfaces; 32% other sources; 22% vehicles; and 5% machinery. Identifying secondary sources of injury provides a more robust understanding of injury sources and scenarios.

For two age groups, aged <5 years and 10–14 years, vehicles accounted for the largest percentage of fatalities (37.5% and 42%, respectively) (Table 2). For youth aged 15–19 years, structure and surface– and machinery-related sources were the leading causes of death (33% and 28%, respectively).

Occupational and nonoccupational fatalities differed significantly by the primary source of injury among youth aged 5 to 19 (Pearson chi-square = 11.398; $df = 3$; $P = .010$). Machinery (44%) was the primary source of occupational fatalities, whereas 0% of the nonoccupational fatalities were due to machinery. In contrast, 42% of the nonoccupational fatalities were categorized as "other," which includes animals, building materials, plants, trees, vegetation, containers, and environmental conditions, whereas only 8% of the occupational fatalities were attributed to this source. The percentages of fatalities due to vehicles for occupational and nonoccupational fatalities were 32% and 25%, respectively.

There was no statistically significant relationship between Anabaptist and Non-Anabaptist youth based on the source of injury ($P > .05$). About 33% and 28% of the Anabaptist youth fatalities and 39% and 11% of the non-Anabaptist youth fatalities were vehicle and machinery sources, respectively. Fatalities from structures and surfaces sources were 14% and 28% of the Anabaptist and non-Anabaptist youth, respectively. The animals and animal-powered vehicles were primary and secondary sources of the fatalities in 31% of the Anabaptist youth. In seven and three Anabaptist cases, animal-powered vehicles (cart, buggy, wagon) were primary and secondary sources of the incidents, respectively. Animals (cattle and other bovines, horses and other equines) were the source of 10 (2 primary and 8 secondary sources) Anabaptist youth fatalities.

TABLE 2. Fatalities by Age Group at Death and Source of Injury in Pennsylvania: 2000–2013 ($N = 82$)

Age group	Machinery		Structures and surfaces		Vehicles		Others	
	A	NA	A	NA	A	NA	A	NA
<5 years	8	1	5	1	12	3	9	1
5–9 years	3	—	1	—	2	2	4	
10–14 years	3	—	—	1	5	—	2	1
15–19 years	4	1	3	3	2	2	1	2
Total	18	2	9	5	21	7	16	4

Note. A = Anabaptist; NA = non-Anabaptist.

From 2000 to 2003, vehicles were the leading source of youth fatality in Pennsylvania (35%); however, between 2009 and 2012, machinery became the leading source (30%). Other sources, which included animal waste products, containers, nonconfined spaces, environmental elements, manure gas, etc., were also a leading cause of youth fatalities between 2009 and 2012 (30%). Between 2000 and 2012, the percentage of fatalities due to vehicle- and structure and surface–related sources declined 9% and 7%, respectively, whereas machinery-related fatalities increased 10%. However, these do not represent statistically significant changes in the percentage of fatalities attributed to these sources ($P > .05$).

Event or Exposure

The event or exposure describes the manner in which the injury or illness was produced or inflicted by the source of injury or illness.[22] For purposes of simplicity, we suggest that there were five major event or exposure types leading to youth farm- and agriculture-related fatalities in Pennsylvania. However, two fatalities were due to violence and other injuries, and these cases were excluded from further statistical analysis. No significant relationships were indicated between age groups and event or exposure type (Pearson chi-square = 10.851; $df = 9$; $P = .286$). The event categories were as follows.

a. Transportation incidents (47.6%, $n = 39$). Transportation events accounted for about one half of the youth fatalities involving tractors, trucks, agricultural machinery, and loaders. Off-road noncollision events, such as overturns and falls from machinery or vehicles, were the leading transportation-related events, accounting for 22 deaths. There were 10 animal transportation fatalities, 3 fatalities as roadway noncollision incidents, and 2 fatalities involved roadway collisions with other vehicle.
b. Contact with objects and equipment (19.5%, $n = 16$). Six of the cases were classified as caught in running equipment or machinery. The other contact events were struck, caught, or crushed in other collapsing structure or equipment and struck by object or equipment.
c. Falls, slips, trips (15.9%, $n = 13$). Eleven cases in this category were falls to a lower level. The other two cases were fall through existing openings.
d. Exposure to harmful substances or environments (14.6%, $n = 12$). Of the 12 cases in this category, 66% of the fatalities involved situations where there was an oxygen deficiency.

About 53% of youth who were involved in fatalities due to a transportation event were less than 5 years old (Table 3). Similarly, 54%

TABLE 3. Fatalities by Age Group at Death and Event or Exposure in Pennsylvania: 2000–2013 ($N = 82$)

Age group	Contact with objects and equipment		Falls, slips, trips		Exposure to harmful substances or environments		Transportation incidents		Violence and other injuries by persons or animals	
	A	NA	A	NA	A	NA	A	NA	A	NA
<5 years	5	1	6	1	5	1	18	3	—	—
5–9 years	4	0	1	0	—	—	4	2	1	0
10–14 years	—	—	1	1	1	1	7	0	1	0
15–19 years	4	2	2	1	1	3	3	2	—	—
Total	13	3	10	3	7	5	32	7	2	0

Note. A = Anabaptist; NA = non-Anabaptist.

of fatalities due to falls, slips, and trips, and 50% of the fatalities due to exposure to harmful substances or environments occurred among children under 5 years of age.

Fatalities to Youth Under 10

More than 60% of the fatalities were to youth under 10 years of age, with 49% under the age of 5 and 15% between ages 5 and 9. Anecdotal evidence suggest that many incidents occur when parents, older siblings, or other family members attempt to supervise or watch toddlers and young children while completing their own work tasks, and/or the child wanders away from direct eyesight of guardians.

To explore this issue more formally, the incident descriptions by all sources for these age groups, 52 incidents in all, were carefully scrutinized. This review suggests that when the incident occurred, 25 (48%) of these children had wandered away, often within the working area. Another 25 children (48%) were not alone at the time of the incident, and in 2 cases (4%) there were inadequate descriptions to make this determination. These 52 cases were also grouped by primary source of injury (Table 4).

Table 4 is constructed, in part, by source and description of the incident. For each source of incident, the description is by event and frequency. Among the victims who were alone, eight drowned after falling into structures and containers such as ponds and troughs (Table 4). In incidents where victims were not alone, they were either passengers (eight cases), working as helpers (six cases), or playing in the area near where their parent or someone was working (11 cases). One occupational case was identified where the victim was alone. In the six occupational cases where victims were not alone, all were reported as helping their parents or relatives.

In the 25 incidents where the victim was not alone, just over one half of cases (13 of 25, 52%) involved the child being run over by a vehicle, including tractors, wagons, and self-propelled machines. When combined with machinery-related incidents, 22 of the 25 cases (88%) were associated with vehicles, machines, and equipment that were being used for work at the time of the incident. The vehicles, machines, and equipment were mobile and being used for work in 13 cases, whereas in 2 cases they were stationery and being used for work. In seven cases, at the time of incident the vehicles, machines, or equipment were being used for transportation, backing up, or kids were playing with them.

DISCUSSION

This study examined trends and patterns of the 82 farm- and agriculture-related fatalities among youth in Pennsylvania from 2000 to 2012. The highest number of fatalities occurred among those whom were 5 years of age or younger and Anabaptist. The fatality rates calculated with these data were different from those found in other research. Goldcamp et al. found that the highest annual fatality rate of 10.4 fatalities per 100,000 youth aged 16 to 19 living and working on US farms.[5] In our study, the highest annual fatality rate of 87.1 fatalities per 100,000 youth were to youth aged <5 years old. The average annual fatality rate in the Goldcamp et al. study for the years 1995–2000, using death certificates only, was 9.3 fatalities per 100,000 youth. Our study in Pennsylvania covering 13 years shows an average annual fatality rate of 26.5 fatalities per 100,000 household youth.

One possible explanation for this difference is the difference between a national study and a single-state study. A single-state study can result in more accurate identification of cases of interest, resulting in higher rates. The use of multiple data sources also increases the identification of cases.

Pennsylvania also has a higher percentage of Anabaptist farm operations than all but one state, which means the involvement of children in farming activities at early ages.[11,15,23] A large number of children working at an early age can only increase hazard and risk exposure to injury. Another possible explanation for our higher fatality rate of 26.5 per 100,000 household youth is that our numerator includes all fatalities that were farm or agriculturally related, whereas our denominator includes only youth

TABLE 4. Source and Description of Events for Youth Under 10 Years Old in Pennsylvania: 2000–2013

Source	*n*	0–4 years
Alone when incident happened ($n = 25$)		
Machinery	2	– Caught in grain mixer (1), soil spreader (1)
	2	– Compressed by front-end loader (1), excavation machinery (1)
Structures and Surfaces	2	– Struck by cattle headlock (1) and metal fence (1)
	2	– Fell into farm pond (2)—drowned
	2	– Depletion of oxygen in feed bin (1) and drowned in manure pit (1)
Vehicles	1	– Run over by tractor driven by 11-year-old brother (1)
	1	– Run over—playing on tractor—thrown out (1)
	1	– Caught by tractor PTO (1)
Others	5	– Fell into watering trough (4), bucket (1)—drowned
	2	– Fell into manure gutter (1), inhaled manure gas (1)
		5–9 years
Vehicles	1	– Compressed/pinched by shifting feed cart he was operating (1)—occupational
	1	– Rollover while using a utility vehicle alone—transportation (1)
Others	1	– Suffocated under grain (1)
	1	– Fell from horse—animal transportation incident (1)
	1	– Struck by a cow (1)
Not alone when incident happened ($n = 25$)		
Machinery	2	– Caught in plowing disk (1), fertilizer spreader—passenger (1)
	2	– Compressed by front end loader (1), skid steer—passenger (1)
	1	– Fell from front end loader (passenger in the bucket)
Vehicles	11	– Run over by tractor (5), wagon (2), truck (2), cart (1), forklift (1)
	1	– Struck by forklift (1)
Others	1	– Struck by rolling barrel (1)
		5–9 years
Machinery	1	– Compressed by machinery-passenger in the bucket of a skid steer (occupational)
	1	– Caught in feed mixer (occupational)
	1	– Hay wrapping equipment (occupational)
Vehicles	1	– Run over—passenger in the tractor (occupational)
	1	– Run over by wagon (transportation)—(occupational)
Structures and Surfaces	1	– Fell from upper level of barn—(occupational)
Other	1	– Crushed under collapsing farm building during demolition
		Unknown if alone or not ($n = 2$)
Structures and surfaces	2	– Fell from barn hay (4 years old)
Others	1	– Fell into silage contaminated water (1 year old)

known to live on a farm. Although we do not have specific data on the living arrangements for each of our victims, our source documents suggest that between 84% and 94% were farm household members, meaning our fatality rate would be reduced only slightly to either 22.3 (84%) or to 24.9 (94%) per 100,000 household.

Beside age, gender was a noteworthy factor among PA youth fatalities. Our study found 80% of the farm- and agriculture-related fatalities to have occurred among males, similar to previous findings.[5,16,24]

Based on the FAIC, we found 30% of the fatalities in Pennsylvania were occupational. This is significantly higher percentage than Goldcamp et al. study of 13%.[5] The higher percentage of occupational fatalities in our study is likely to be a result of multiple and more detailed information sources for each case, and the presence of Anabaptists in Pennsylvania. A previous study has noted that there may be

nearly a 30% difference in designating agricultural occupational fatalities when supplemental sources to death certificates were used.[25] In our study, the occupational fatality percentage among Anabaptist was 33%. In a study that used a similar methodology for coding and collecting data (i.e., use of supplemental data sources and FAIC code to determine whether a fatality was occupationally related), 43% of the Anabaptist youth fatalities classified as occupational.[16]

In regard to primary source of fatal injury, the majority of fatalities occurred due to vehicles (34%) and machinery (24%), similar to the previous research. Goldcamp et al. also found that machinery constituted 25% of the fatalities, and Adekoya and Pratt reported that 36% of farm fatalities were caused by machinery (including farm tractors) in United States.[5,24]

By including primary and secondary sources, researchers were able to be more inclusive of all causes of death. For instance, in the vehicle category, farm tractors were either a primary or secondary source in 18% of the cases. However, if only the primary source is considered, tractors were involved in 12% of the incidents. Likewise, animals and animal-powered vehicles were a primary or secondary source of the fatality in 24% of the cases, but as a primary source they were only 13% of fatalities. It was also found that 31% of the fatalities to Anabaptist youth were directly or indirectly associated with animals. This finding was also affirmed by a previous study where 33% of the all fatalities to Amish adults and children were related to animal behavior.[23]

Transportation events accounted for more agricultural fatalities of youth than any other events or exposure, regardless of whether the fatality was occupational or nonoccupational. This finding is consistent with previous research by Castillo et al. that used Bureau of Labor Statistics (BLS) data to describe fatal agricultural work–related injuries among youth under 20 years of age.[26]

Our data show there were dangers of young children being exposed to farm machinery and vehicles, even in the presence of adults. Other studies have also shown that children exposed to the agricultural worksite were seriously injured or killed even in the presence of supervision.[27,28] It was stated that it is challenging for adults engaged in agricultural work to simultaneously supervise young children in the attentive, proximal, and continuous manner that may be necessary to protect them from harm. To be able to work and supervise young children simultaneously is difficult at best and appears to lead to tragedy in many instances. Our data suggest that this danger is even more pronounced among Amish farm households. As stated by Rhodes and Hupcey,[14] even children as "gifts of God" still need to be protected from harm if they are to avoid becoming another farm injury statistic. The presence of children in and around farm work areas is incongruent with the expressed desire of Amish parents to protect their children from harm as they experience daily life. There is a need to work effectively with Anabaptist groups to collaboratively find ways to protect their children while respecting their cultural beliefs.

Recommendations for properly supervising young children on farms[29] and developing safe play areas[30] are readily available from the National Children's Center for Rural and Agricultural Health and Safety.[31] Educational programs and outreach activities for youth safety have increased tremendously over the past 25 years and include both the public and private sectors.[32] It may be that some farm parents in Pennsylvania, including Amish parents, are not receiving this information, choose not to follow such recommendations, or face cultural barriers that inhibit adoption of the recommendations.

STUDY LIMITATIONS

Some limitations regarding the data and analyses in this report should be kept in mind. Although we have farm household population data, we do not have number of hours worked or other exposure indices. Nor do we have an exact estimate of the number of youth working but not living on the farm or youth visitors to the farm. These data would be helpful for comparing work injury data among other agricultural populations and other cohorts of youth. Another limitation was that although we have confidence in our ability to designate whether a case was

Anabaptist or not, we did not follow up with next of kin to make a final determination. Mitigating this limitation to some degree was a previous research project that did involve follow-up with next of kin for all potential database fatality cases in Pennsylvania. This unpublished study indicated, when compared with existing data in the Penn State fatality database, additional follow-up did not significantly impact important case variables. Finally, newspaper accounts of injury incidents were not always completely accurate in their use of agricultural terms for machines, equipment, structures, buildings, and the like, or in their descriptions of what actually occurred. The use of multiple sources for all cases entered into the Penn State Farm and Agricultural Injury Database helped to minimize this type of error.

SUMMARY AND RECOMMENDATIONS

The Penn State Farm and Agricultural Injury Database provided information about fatal farm injuries in Pennsylvania. Coding cases according to the OIICS and FAIC is an available methodology to most state-level researches and allows comparison of data among states. Youth are exposed to hazards while not just working but also living on the farm. Thus, the fatality sources, events, and fatality rates have to be examined regardless of whether the fatality is occupational. Our database included all farm- and agriculturally related occupational and nonoccupational fatalities to youth, and we were able to analyze the occupational and nonoccupational data. Such data provide important information for establishing safety education and injury intervention priorities. Some key findings from our study are the following:

- Children under 5 years of age were at especially high risk of a fatal farm injury as this group made up nearly 50% of the total number of fatalities among those 19 and under.
- Thirty percent of all fatalities were occupational, 62% were nonoccupational, and 7% undetermined.
- The majority of youth (78%) involved in a farm- and agriculture-related fatality were Anabaptist, and they were more likely to have occupational fatalities than nonAnabaptists.
- Vehicle and machinery incidents were the primary sources of fatal injuries (34% and 24%, respectively). Occupational and nonoccupational fatalities significantly differed by the primary source of injury for youth 5 to 19 years of age. This was particularly evident in the machinery classification where 44% of the cases were the primary source of the occupational fatality, whereas there were no nonoccupational fatalities due to machinery. However, the percentages of occupational and nonoccupational fatalities due to vehicles were 32% and 25%, respectively.
- The most common secondary source category was structures and surfaces (15 of 37 identified cases; 41%).
- From 2000 to 2003, vehicles were the leading source of youth fatality in Pennsylvania; machinery and other sources were the leading sources between 2009 and 2012. However, these differences were not statistically significant.
- Transportation events were the most frequently occurring events or exposures leading to a fatal injury (48%), followed by contacts with objects and equipment (20%), falls, slips, and trips (16%), and exposure to harmful substances and environment (15%).
- From the descriptions of the incidents, about one half of the youth under 10 years old were alone at the precise time of incident. In cases where they were not alone, they were primarily either a passenger on farm machinery or otherwise exposed to mobile equipment.

Based on the findings presented in this paper, we offer the following suggestions for addressing fatal injury incidents among youth on farms in Pennsylvania:

- With most of the fatalities occurring to youth under 5 years of age, strategies for

preventing fatalities to this group must become a priority. This is especially true for Anabaptist sects.

- The majority of youth fatalities were due to vehicles or machinery (58%); one half of these incidents were to youth under the age of 5 (50%) and nearly two thirds of the total cases (62%) were nonoccupational. Vehicular and machinery safety remains an important topic for reducing fatalities among youth of all ages, including those under 5 years of age.
- Safety programs for structures and surfaces (18%) are also needed.
- Descriptions of the injury incidents suggest that many parents were trying to supervise their children while they completed work tasks. Parents supervising children (especially young children in the workplace) puts children at undue risk of death/injury. Ideally, all of the incidents to youth under the age of 5 and most of the incidents to youth aged 5 to 9 could have been prevented with the use of safe play areas. However, safe play areas without appropriate supervision are still problematic. Opportunities to help parents provide both safe play areas and appropriate supervision needs to be explored.

This paper also helps to illustrate the value of state-based monitoring of farm injury to youth using methods available to many states and territories (i.e., using OIICS and FAIC to classify agricultural injury/fatality data).

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NOTE

i. The population of Ohio and Pennsylvania numbered 11,570,808 and 12,773,801, respectively, in 2013 (US Census Bureau: State and County QuickFacts. Data derived from Population Estimates, American Community Survey, Census of Population and Housing, State and County Housing Unit Estimates, County Business Patterns, Nonemployer Statistics, Economic Census, Survey of Business Owners, Building Permits Last Revised: March 27, 2014).

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APPENDIX A

FAIC Code Categories

1. FAIC-1, Farm Production Work (NAICS 111, Crop Production; 112, Animal Production): Victim engaged in work activity related to agricultural production.
2. FAIC-2, Forestry and Logging (NAICS 113): Victim engaged in work related to growing and harvesting timber on a long production cycle (i.e., of 10 or more years).
3. FAIC-3, Fishing, Hunting & Trapping (NAICS 114): Victim engaged in a work activity related to commercial fishing, hunting or trapping (NAICS 114). These industries involve harvesting fish and other wild animals from their natural habitats and are dependent upon a continued supply of the natural resource.

4. FAIC-4, Agricultural and Forestry Support Activities (NAICS 115): Victim engaged in work activity related to custom hired and contracted services that are an essential part of agricultural and forestry production (NAICS 11511–115310).
5. FAIC-5, Farm Hazard Exposure, outside services: Victim associated with a business or service and injured on a farm while providing services to the farm.
6. FAIC-6, Farm Hazard Exposure, Nonworkers: Equipment, Tools, Objects & Products. Victim engaged in an activity involving agricultural machines, equipment, tools, products, etc., but not related to farm production operations.
7. FAIC-7, Farm Hazard Exposure, Nonworkers: Structures and Landscape: Victim not actively engaged in a work activity but injured as a result of exposure to hazards of farm structures and landscape.
8. FAIC-8, Farm Hazard Exposure, Nonworkers: Animals: Victim not actively engaged in a work activity but injured as a result of exposure to agricultural animal hazards.
9. FAIC-9, Farm Hazard Exposure: Roadway Collision: Victim not actively engaged in a work activity but injured as a result of collision with agricultural hazard on roadway.