2017 Summary of U.S. Agricultural Confined Space-Related Injuries and Fatalities

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Introduction

This publication represents continued efforts by Purdue's Agricultural Safety and Health Program to gain a better understanding of injuries and fatalities that occur while working in or around agricultural confined spaces, including grain storage and handling facilities. The purpose of these efforts is to contribute towards the reduction in the frequency and severity of these incidents, by keeping the problem in the public's attention. This summary is based on data gathered, documented, and entered into Purdue's Agricultural Confined Space Incident Database (PACSID). Partial support for this year's surveillance effort was again provided by The Grain Journal (www.grainnet.com).

No fewer than 54 fatal and non-fatal cases involving agricultural confined spaces were documented in 2017. Of these, 23 (43%) of the cases were fatal and 23 (43%) were directly related to grain entrapments. In addition to the cases documented in 2017, cases that occurred in previous years continue to be added to the database due to ongoing discovery efforts. The total number of cases[1] documented between 1962 and 2017 and entered in the PACSID is 1,989. Of those, 1,187 cases (61%) were reported as fatal and 1,432 (74%) involved grain storage and handling facilities. As noted in past summaries, the data presented do not account for all incidents involving agricultural confined spaces. There is no accumulative public record of these incidents due to the fact that there is no comprehensive or mandatory incident/injury reporting systems for most of agriculture; in addition, there has been reluctance on the part of some victims and employers to report "near-misses" or non-fatal incidents, especially at farms, feedlots and seed processing operations not covered by federal OSHA injury reporting requirements. It is estimated that approximately 30% of cases go unreported.

[1] There is one case in the database that occurred in 1956.

2017 Summary of All Documented Agricultural-Confined Space-Related Cases

In 2017, there were 23 documented grain entrapment cases[2], 9 reported falls into or from grain storage structures, 2 asphyxiations due to deficient oxygen levels or toxic environments, and 8 equipment entanglements, such as those involving in floor and sweep augers, that occurred while working inside or around agricultural confined spaces (Figure 1). Other incidents involved silos, manure pits and pump pits. Grain entrapments accounted for 43% of the documented cases. For incident types with more than one case, asphyxiations and entrapments had the highest fatality rate reported at 100% and 52% respectively. The number of fatal cases was only slightly lower than the number of non-fatal cases for all confined space incidents, further suggesting an under reporting of non-fatal incidents.. The 5-year and 10-year averages for non-fatal cases was 33.60 and 36.80 cases/year respectively. The 5-year and 10-year averages for fatal cases was 26.80 and 30.70 cases/year respectively. In comparison, in 2017 non-fatal cases (31 cases) were below average for both metrics, and fatal cases (23 cases) were either above or at average. It is speculated that the increase in percentage of fatalities could be due to a significant drop in the number of identified reports of non-fatal cases.

The total of 54 confined space cases represented an 11% decrease from the number of cases documented in 2016, when 60 were recorded. This places the number of this year's confined space-related cases below the 5-year average (59.20 cases/year) and substantially below the 10-year average (67.50 cases/year). The 5-year running average for all agriculture-related confined space-related cases continued to decrease from its peak in 2011 of 75.8 cases/year to 59.2 cases/year; thus was the lowest reported five-year average since 2008. This marks the first significant decrease since the five-year average started to steadily increase in 2002 from 36.8 cases per year. A significant contributing factor in the earlier increase in the frequency was attributed to better documentation of incidents due to more aggressive surveillance efforts and increased access to case information via the internet.

[2] A case refers to one individual. Some incidents involved multiple individuals or cases.

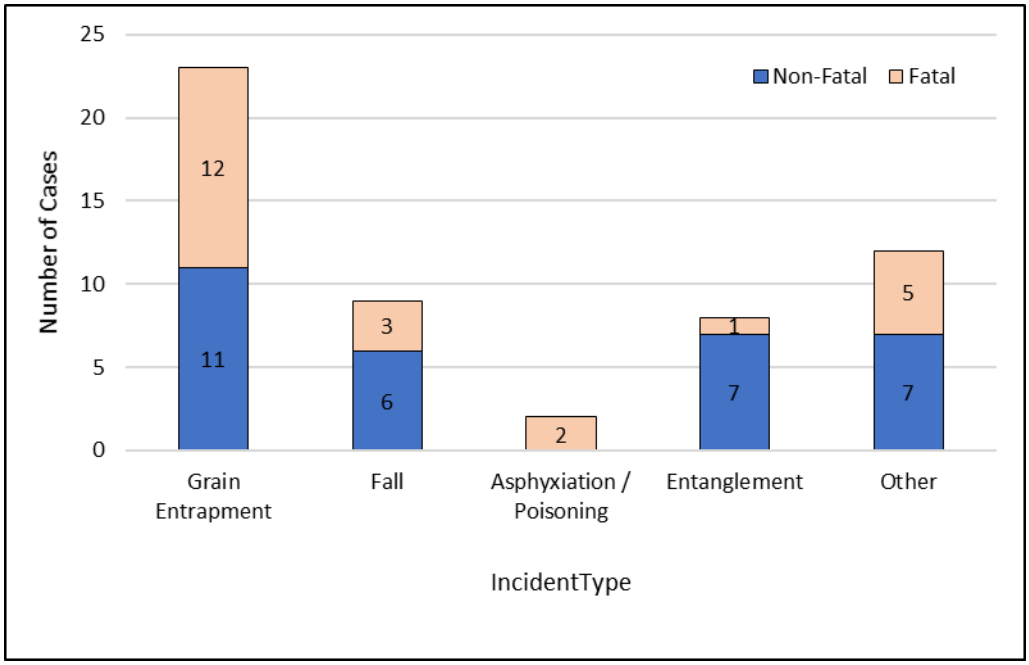

Figure 1: Distribution of all 2017 agricultural confined space-related cases by type of incident, N = 54.

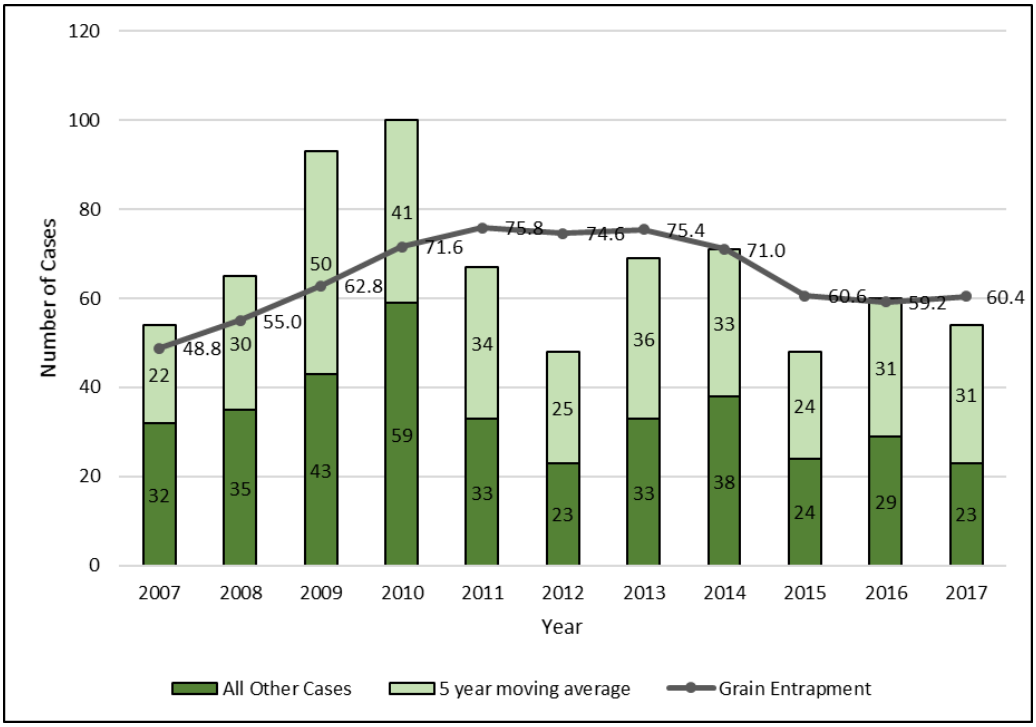

Figure 2: Number of all annual confined space cases recorded between 2007 and 2017.

In 2017, the states with the most documented confined space cases of all types, including fatal and non-fatal, were Wisconsin (14), Iowa (9) and Minnesota (5). There were four cases documented in Illinois and Texas, three cases for Nebraska and two for Indiana, Kansas, Kentucky and Ohio. Overall, incidents were documented in 17 states in 2017, slightly less than the 21 states reporting incidents in 2016. Figure 3 illustrates the geographic distribution of all documented cases in the PACSID and those documented in 2017. The three states with the largest number of cases were Iowa (237), Indiana (222) and Minnesota (190). As noted in previous summaries, it is estimated that this surveillance effort underreports cases by as much as 30% due to the lack of adequate reporting mechanisms.

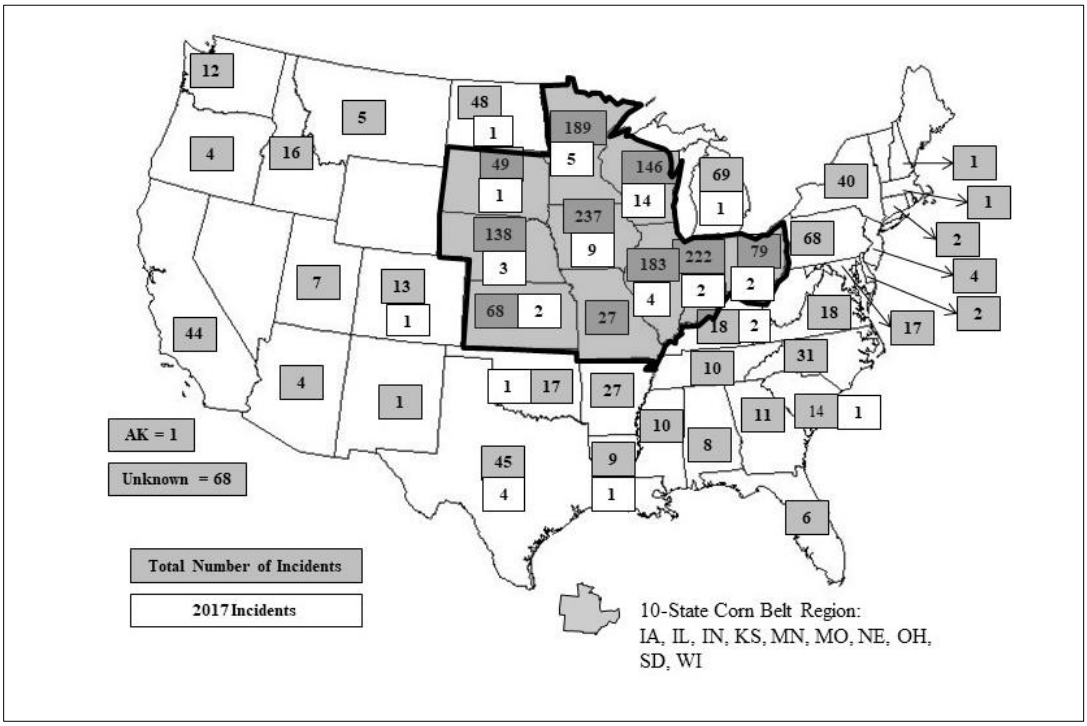

Figure 3: Geographic distribution of all confined space cases for 2017 and previous years (n=1989).

There was one case in 2017 in which the gender was female and the remaining cases all involved males. This female case involved to a girl under the age of 18..

In total, there were four cases involving a child or youth under the age of 21, as shown in Figure 4. Overall, a specific age was known for 38 of the 54 victims in 2017, with the oldest victim being 88 and the youngest three years old. The average age was 47.2 years old, and the median age 52 (Figure 4). Those over the age of 60 accounted for 8 (21%) of the 38 cases (where age was known), reflecting the increasing average age of farmers (58 years old) in the

U.S. As noted, a large number of the cases documented (16) did not include the specific age of the victim.

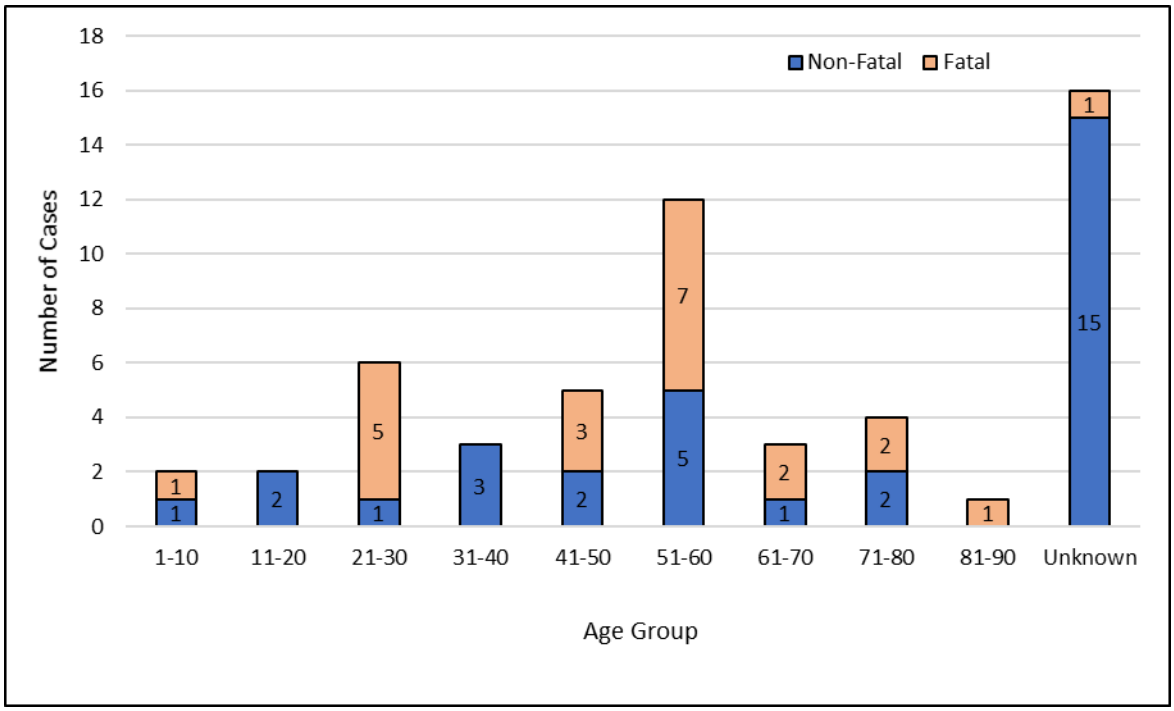

Figure 4: Age distribution of all 2017 agricultural confined space incident victims by number of cases recorded.

In 2017, there were 26 cases where the exemption status[3] of the facility with respect to OSHA regulations was known. Of those, 22 (41%) occurred on farms or other locations currently exempt from compliance with the OSHA Grain Handling Facilities Standards (29 CFR 1910.272) or Confined Space Standards (29 CFR1910.146), with the balance of (48%) taking place at non-exempt commercial grain facilities which is consistent with recent trends. It is important to note that there were only six cases in 2017 in which the exemption status was unknown; and it is believed that the majority of the unknown cases, based on historical data, have OSHA exempt status.

As in the past, a comparison was made between agricultural confined space incidents and mining incidents. In 2016, there were 25 fatal mining incidents and 30 fatal agricultural confined space incidents. In 2017, however, the number of reported fatal incidents in mining (28)

[3] Under the current provisions of the two OSHA workplace safety and health standards most relevant to agricultural confined spaces, most agricultural worksites, including most farms, feedlots, and certain seed processing operations are exempt from compliance.

exceeded the fatal agricultural confined space incidents (23). Historically there have been more fatal mining incidents than those occurring in agriculture.

Grain Entrapments

The 23 fatal and non-fatal grain entrapment cases documented in 2017 represented a 26% decrease from 2016 when 29 were recorded. The total number of cases documented in 2017 is lower than the 5-year average (29.4 cases/year). Note, the 5-year running average continues to drop from its peak of 40.4 in 2011 (Figure 5). The number of fatal cases (11) is the second lowest recorded since 1985; only 2012 reported a lower number of cases (8). While, the number of non-fatal cases (12) was the fourth largest ever recorded after 2010 (27), 2011 (21), 2013 (21), and 2014 (20). The fatality rate was 48%, lower than 5-year average. In 2017, the state with the most documented grain entrapments, fatal and non-fatal, was Iowa with seven cases total. This was followed by Wisconsin (3), Minnesota (2), Texas (2), and the remaining 9 states had one each. Overall, grain entrapments were documented in 13 states in 2017. The majority of grain entrapment cases occurred in the Midwest, or Cornbelt (70%), which was lower than last year during which 77% occurred in the Midwest. Overall, 74% of previously document cases have occurred in the Midwest. Figure 6 provides a geographic distribution of all documented grain entrapment cases contained in the PACSID where the location was known. Indiana continues to have the highest number of documented grain entrapment cases. It is believed that this high number reflects more aggressive surveillance efforts in Indiana to document both fatal and non-fatal cases over the past 40 years rather than an actual larger number of cases. It is believed that Iowa, Illinois, and Minnesota should have a substantial higher number of cases based on both total grain production and grain storage capacity.

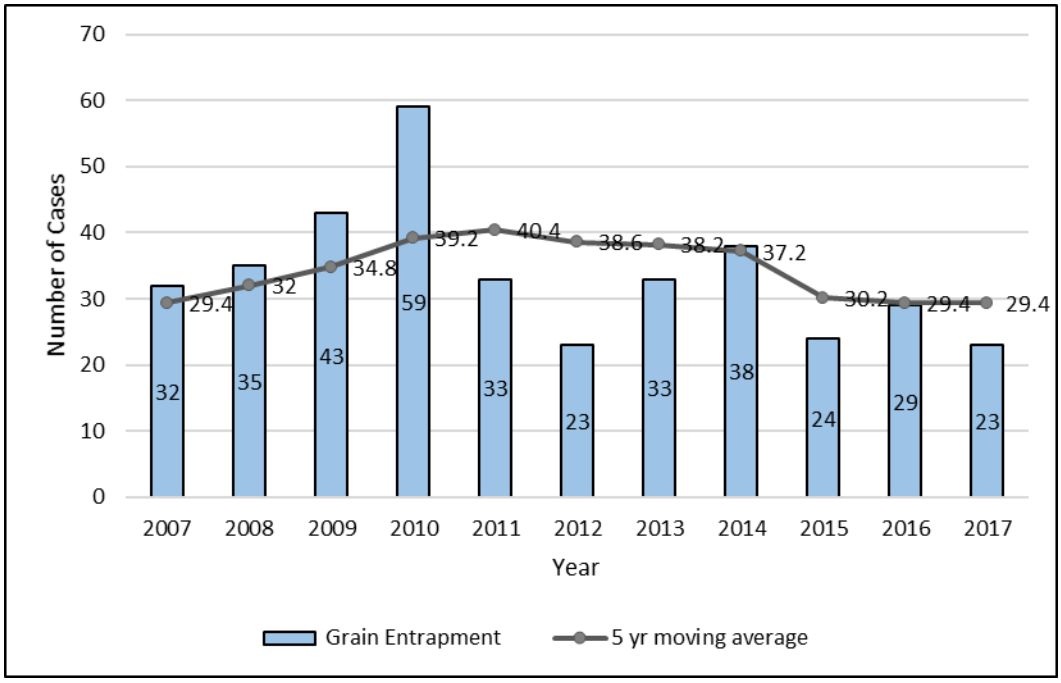

Figure 5 Number of annual grain entrapment cases recorded between 2007 and 2017

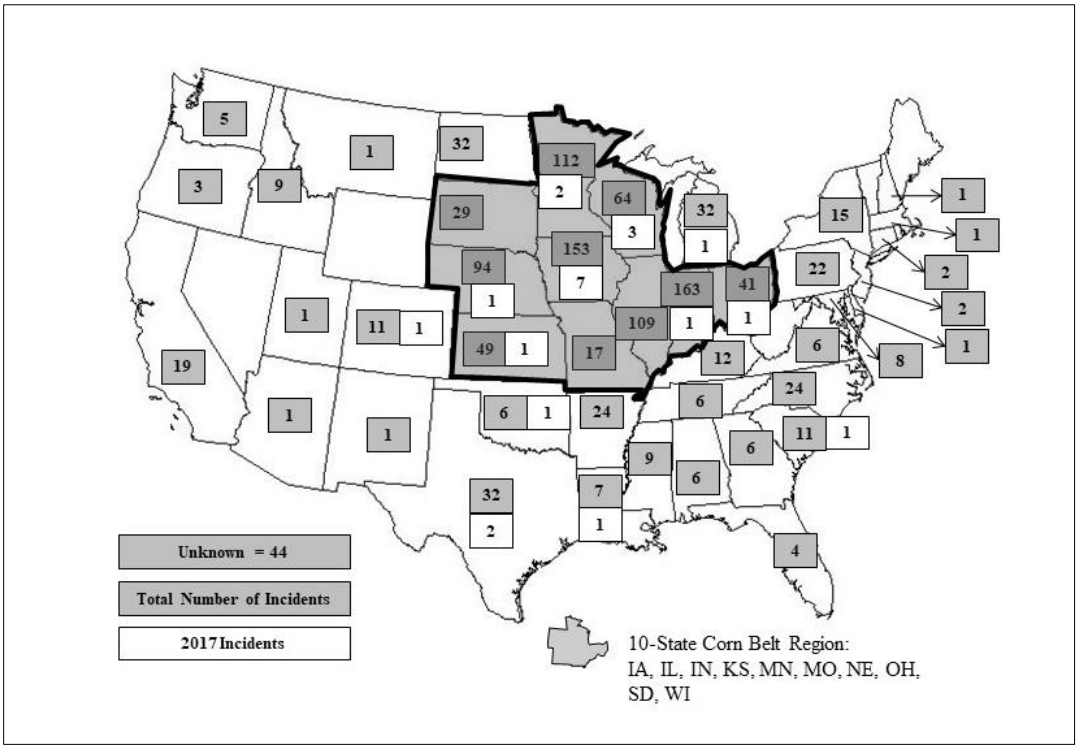

Figure 6: Geographic distribution of grain entrapment cases for 2017 and previous years (n=1195).

There was only one female victim with the remaining cases being male. There were no grain entrapment case involving a youth under the age of 21, an age group that has accounted for as many as one in five cases in the past. The oldest victim was 88. The average age was 49 years old and the median age 54. Two cases of grain entrapments occurred in grain transport vehicles (GTV) and both resulted in fatality.

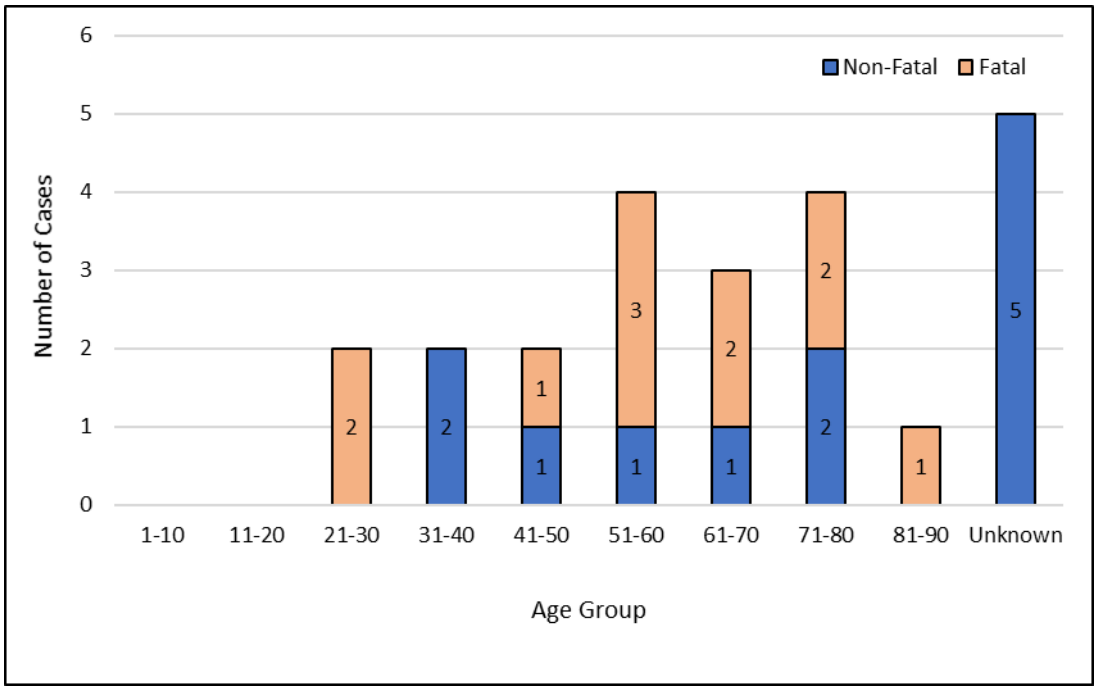

Figure 7: Age distribution of 2017 grain entrapment victims by number of cases recorded.

As in past years, it should be noted that this summary does not reflect all grain-related entrapments, fatal or non-fatal, that have occurred. Currently, over two-thirds of grain storage capacity in the U.S. is found on farms that are exempt from the current OSHA injury reporting requirement standards.

Using Children and Youth in Grain Safety/Rescue Training Activities

Through the ongoing surveillance efforts, cases were identified in which fatalities or injuries were documented as the result of involving children and youth as live "victims" in safety demonstrations, grain rescue training, or recreational/educational activities. This has included two male victims, age 6 and 13, who asphyxiated in free flowing grain during an educational visit to a farm. In addition, cases were reported and documented in which children and youth

were being deeply entrapped in grain, up to their shoulders, to demonstrate the effects of entrapment and to conduct extrication training for emergency first responders. A review of on-line sources found that this practice was more widespread than originally believed with literally hundreds of images showing children, including infants, being partially buried in grain. The issues raised by these practices include the potential for:

- Choking and asphyxiation
- Exposure to respiratory hazards, asthma triggers
- Excessive pressure on the chest and breathing difficulties
- Claustrophobia/emotional trauma
- Injuries related to emergency extrication

As the result of these findings, an editorial was published in the April 2018 (Vol. 24 No. 2) issue of the Journal of Agricultural Safety and Health calling for an end to the use of children and youth, and others uninformed regarding the hazards of flowing grain, as "victims" in flowing grain demonstrations. There is no evidence to justify the need for or the value of placing children and youth at risk of harm, even if volunteered by a parent or guardian to participate. On the contrary there is research to suggest that presenting a recognized hazardous activity as recreational or fun, may, in fact, result in a lower appreciation of the potential risks involved. It is recommended that mannequins be used in flowing grain demonstrations and that safety professionals on-site where live "victims" are being used step up and intervene on behalf of those being placed in harm's way.

Summary of Manure Storage, Handling, and Transport Equipment and Facility Incidents

As part of ongoing surveillance of fatalities and injuries involving agricultural confined spaces by Purdue University's Agricultural Safety and Health Program, nearly 300 cases involving manure storage, handling and transport equipment and facilities have been documented over the past 30 years. With the exception of a summary of 77 fatalities published by Beaver (2005), these cases have not been completely entered into the Purdue University Agricultural Confined Spaces Incident Database (PACSID) or summarized due to a lack of resources and the limitations in the design of the database because of its origin as a means to store incidents involving grain storage, handling, and transport operations. The differences in terminology used in the current database and dissimilar causative and contributing factors were a significant barrier.

In order to develop a consistent approach to process and analyze the data, 16 U.S. incidents involving 36 victims documented as having occurred in 2017 were examined for type of incident, victim characteristics, primary contributing factors and nature of injuries. A pilot analysis was completed and results were summarized. This pilot exercise resulted in a classification rubric for coding and analysis of descriptive information regarding each case. The final methodology will be used to analyze all historically documented incidents, as well as future incidents.

Of these 2017 cases, 21(58%) cases were fatal. There were six incidents involved multiple victims, two victims in one case and three victims were reported in another, and in two incidents there were four. As with confined spaces in general, the risk of multiple victims is higher than for other types of farm-related incidents.

The cases were primarily work-related but also included ten cases that were classified as non-work, including the death of a three year old male who drowned after falling into an open manure pit. All of the victims in 2017 were male with an average age of 33 which is younger than the average for all grain-related victims, 53.

The distribution of agents involved in 2017 is showed in Figure 8. There were 21 cases with known causes, including 8 cases involving manure handling equipment, the most frequently identified agent, and 5 cases involved in manure transport equipment.

The type of toxic gas the victim(s) were exposed to was rarely confirmed, but in prior research it appears that oxygen deficiency and the presence of hydrogen sulfide are significant contributors to fatalities in these cases.

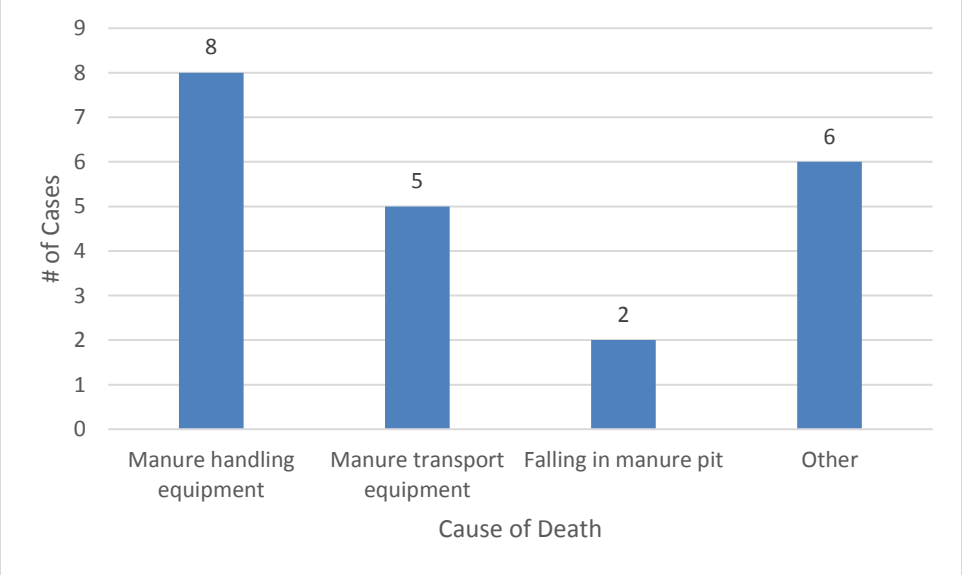

Figure 8: The distribution of cause of deaths in manure-related cases (N=21).

Analysis on the Distribution of Incident Type and Facility by US and OSHA Regions.

Confined space-related cases have occurred in every OSHA region but are mainly condensed in two regions, region 5 and 7. Region 5 accounted for 45% of all agricultural confined space cases (888) with 59% of those cases being grain entrapments, and 13% being falls. Region 7 contains 24% (470) of all cases with grain entrapments, asphyxiation and entanglements representing 67%, 10% and 10% of those cases respectively. Region 1 represented the region with the smallest number of grain entrapments and region 4 represents the region with the largest percentage of total documented cases being grain entrapment cases (72%).

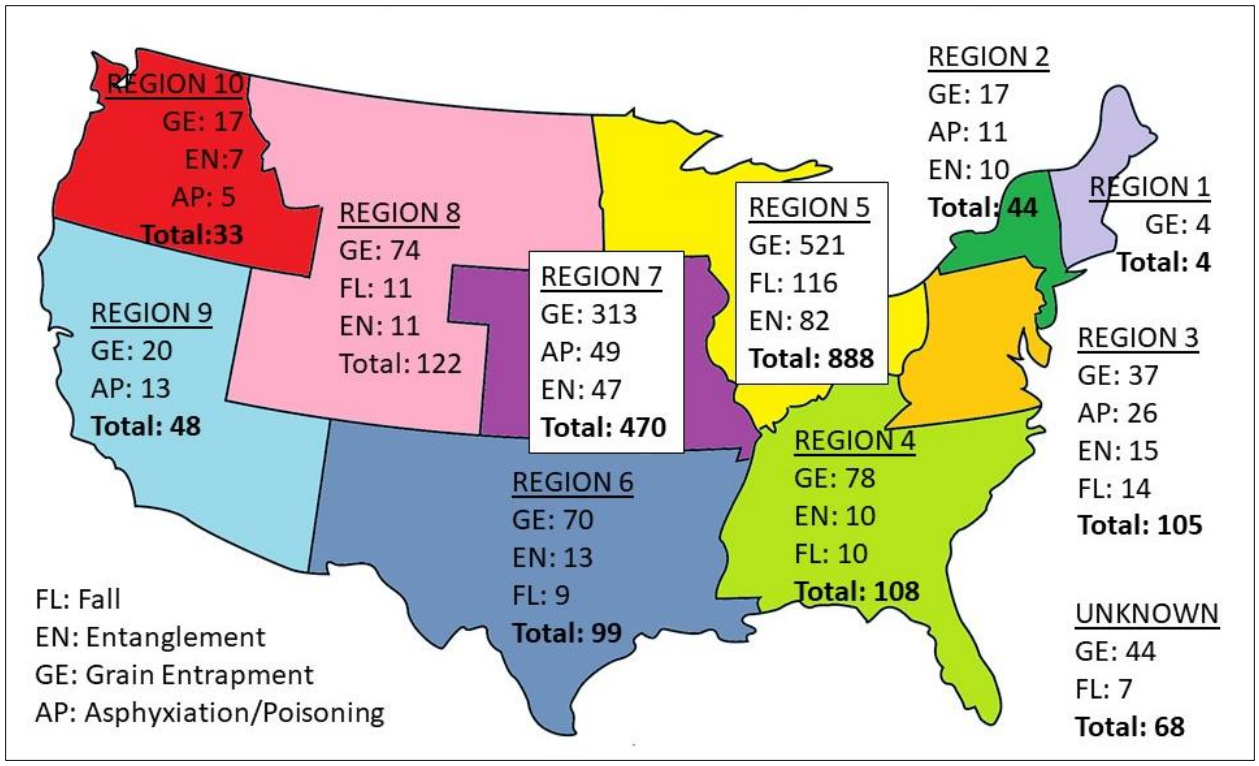

Figure 11: Agricultural confined case distribution by OSHA region from 1962-2017. The total number of cases and most frequent type of case is listed for each region (n=1989).

Observations

The following observations highlight several significant findings.

- No fewer than 54 fatal and non-fatal cases involving agricultural confined spaces were documented in 2017, representing an 11% decrease over 2016.

- 43% of all cases documented involved grain-related entrapments as compared to other cases involving falls, entanglements, and asphyxiations.
- 43% of 2017 cases were fatal compared to 61% historically.
- Iowa, Wisconsin, Illinois and Texas reported the most cases in 2017 with Iowa, Indiana, and Minnesota being the overall leaders historically.
- There were 23 grain entrapments in 2017 representing a 26% decrease over 2016.
- Iowa, Wisconsin, Minnesota and Texas reported the most grain-entrapment cases in 2017. Historically, Indiana, Iowa, and Minnesota and Illinois have reported the most cases.
- No grain entrapments in 2017 involved children and youth under the age of 21.
- OSHA Region 5 and 7 have accounted for 68% of all documented agricultural confined space-related incidents.

Project Website

With support from a Susan Harwood Grant from the U.S. Department of Labor, a unique website was developed (www.agconfinedspaces.org). The purpose of this site was to provide resources for those conducting safety and health training in the area of agricultural confined spaces, especially in the area of grain storage and handling hazards. Training resources, frequently asked questions, past summaries of injuries and fatalities and an extensive bibliography can be found at the site. Since it was put online in 2013, it has hosted over 10,000 visitors.

One of the most frequently visited resource on the website is the curriculum developed for young and beginning workers in the grain industry (called **Against the Grain**). The goal of this teaching resource is to provide agricultural and safety educators with an evidence based 3-5 hour training program to present basic awareness safety and health training to youth, ages 16-21, who are employed at grain handling and storage facilities, including both exempt and non-exempt operations. The curriculum has been delivered to over 4500 youth in both secondary school agricultural education programs and informal, out-of-school settings. Pre- and post-testing have demonstrated a significant knowledge gain and instructor feedback has been very positive. The complete curriculum is available as a free download.

The second education resource at the site is designed for use in training emergency first responders to safely respond to incidents at grain storage and handling facilities. Over the past

six years over 4100 emergency first responders have participated in training using this material. This curriculum is also available as a free download.

Published Works

As the result of the analysis of the data gathered over the past six years, the following articles have been published. Full text for some of these articles are available at www.agconfinedspaces.org.

Roberts, M. J. Field, W. E., Maier, D. E., Stroshine, R. L. Determination of Effort Required to Insert a Rescue Tube into Various Grain Types. ***Journal of Agricultural Safety and Health***, 18:4, 2012.

Riedel, S. M., Field, W. E. Summation of the Frequency, Severity, and Primary Causative Factors Associated with Injuries and Fatalities Involving Confined Spaces in Agriculture. ***Journal of Agricultural Safety and Health***, *19*(2), 83-100, 2013.

Field, W. E., Heber, D. J., Riedel, S. M., Wettschurack, S. W., Roberts, M. J., Grafft, L. J. Worker Hazards Associated with the Use of Grain Vacuum Systems. ***Journal of Agricultural Safety and Health***, 20(3), 147-163, 2014.

Issa, S.F., Field, W.E., Hamm, K.E., Cheng, Y.H., Roberts, M.J., and Riedel, S.M. Summarization of Injury and Fatality Factors Involving Youth and Grain Entrapment or Engulfment in Agriculture. ***Journal of Agricultural Safety and Health***, 22(1), 13-32, 2016

Roberts, M. J. Field, W. E., Maier, D. E., Stroshine, R. L. Determination of Entrapment Victim Extrication Force with and without Use of a Grain Rescue Tube. ***Journal of Agricultural Safety and Health***, 21:2, 2015.

Issa, S.F., Cheng, Y.H., and Field, W.E. Summary of Agricultural Confined Space-related Cases: 1964-2013. ***Journal of Agricultural Safety and Health***, 22(1), 34-45, 2016.

Cheng, Y.H. and W.E. Field. Summary of Auger-related Entanglements Occurring Inside Agricultural Confined Spaces. ***Journal of Agricultural Safety and Health***, 22:2, 2016.

Issa, S.F., Field, W.E, Schwab, C.V., Issa, F.S., Nauman, E. Contributing Causes of Injury or Death in Grain Entrapment, Engulfment and Extrication. ***Journal of Agromedicine***, 22:2, 2017.

Issa, S.F. and Field, W.E. Determining the Pull-Forces Required to Extricate a Victim Entrapped at Various Angles in a Grain Mass. ***Safety***, Accepted for publication, 2017.

Cheng, Y.H., Field, W.E., Tormoehlen, R.L., French, B. Utilizing Secondary Agricultural Education Programs to Deliver a Grain safety Training for Young and Beginner Workers. ***Journal of Agromedicine***, 22:4, 2017.

Issa, S.F., Nauman, E., Wassgren, C., Schwab, C.V., Ahsan, Z.S., Field, W.E. Measured Spine Tensile Force Limits for Extracting Grain Entrapped Victim. Submitted to Journal of Safety.

Field, W.E., Cheng, Y.H., Tormoehlen, R.L., Aherin, R., Schwab, C., Neenan, D., Roberts, M. Let's Stop Treating Our Youth Like Dummies. Editorial. ***Journal of Agricultural Safety and Health***, 24:2, 2018.

Issa, S.F., Nour, M.N., Field, W.E. Utilization and Effectiveness of Harnesses and Lifelines in Grain Entrapment Incident's; Preliminary Analysis. ***Journal of Agricultural Safety and Health***, 24:2, 2018.

Cheng, Y.H., Field, W.E., Issa, S.F., Kelly, K., Heber, M., Turner, R. Summary of U.S. Injuries and Fatalities Involving Entrapment and Suffocation in Grain Transport Vehicles. ***Journal of Agricultural Safety and Health***, 24:2, 2018.

Issa, S.F., Wassgren, C., Schwab, C.V., Stroshine, R., Field, W.E. Estimating Passive Stress Acting on a Grain Entrapment Victim's Chest. ***Journal of Agricultural Safety and Health***, 24:3, 2018.

For additional information on this report, contact Professor Bill Field at 765-494-1191 or field@purdue.edu. In addition, refer to these sources for more information on this topic:

- www.agconfinedspaces.org
- www.grainsafety.org
- www.grainentrapmentprevention.com
- http://apps.npr.org/buried-in-grain/