

2019 Summary of U.S. Agricultural Confined Space-Related Injuries and Fatalities

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Highlights

The following are highlights from the 2019 findings.

- No fewer than 67 fatal and non-fatal cases involving all types of agricultural confined spaces were documented in 2019, representing a 9.8% increase over 2018.
- There were 38 grain entrapments in 2019 representing a 26.7% increase over 2018.
- 56.7% of all cases documented involved grain-related entrapments as compared to other cases involving falls, entanglements, and asphyxiations in all types of agricultural confined spaces.
- All documented cases were male.
- 58.2% (39) of 2019 cases were fatal compared to 61% historically.
- Minnesota, Iowa and Nebraska reported the most cases in 2019. Historically, Iowa, Indiana, and Minnesota have recorded the most agricultural confined space cases.
- Minnesota reported the most grain-entrapment cases in 2019. Indiana, Iowa, Minnesota, and Illinois have recorded the most grain entrapment cases over time.
- Eight cases in 2019 involved a youth under the age of 21, of which five involved manure handling or storage.
- OSHA Region 5 and 7 have historically accounted for 68.4% of all documented agricultural confined space-related incidents.
- The number of agricultural confined space-related fatalities documented exceeded the number of mining-related fatalities in 2019 (39 versus 24).

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Introduction

Since the 1970's Purdue University's Agricultural and Biological Engineering Department has been documenting and investigating incidents involving grain storage and handling facilities at both commercial and on-farm locations. Beginning in 2013, the effort was expanded, with support from a U.S. Department of Labor Susan Harwood Training Grant, to include incidents involving grain transport vehicles (trucks, wagons, railcars); injuries occurring inside of confined spaces due to exposure to powered mechanical components, such as augers; falls from or into confined spaces; and other types of agricultural confined spaces including forage storage silos, liquid storage tanks, and manure storage facilities.

All documented cases have been reviewed by a team of experts to ensure elimination of duplicates, assign case information to specific coding categories, and to identify potential contributing factors. Data were derived from a wide range of sources including online searches, news clippings from local sources, work product from civil litigation, published personal accounts, and death certificates (during early years). The data were coded using a coding form developed and tested by Riedel and Field (2013). Coded data were entered into the Purdue Agricultural Confined Space Incident Database (PACSID) allowing for summarization.

As of the end of 2019, the PACSID contained information on 2,117 cases documented¹ between 1962 and 2019² that resulted in an injury, fatality, or required emergency extrication by first responders. Of these cases 1,276 (60%) were fatal with 1,496 (71%) involving grain storage and handling facilities. Figure 1 provides a breakdown of cases by facilities involved.

¹ A case refers to one individual. Some incidents involve multiple victims or cases.

² There is one case in the database that occurred in 1956.

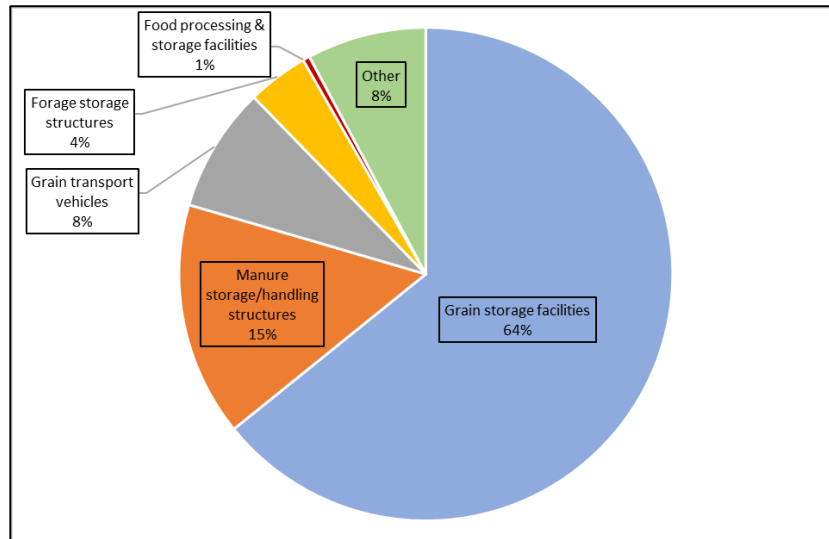


Figure 1: Distribution of all agricultural confined space-related injuries and fatalities in PACSID database based on agent category.

As noted in past summaries, the data presented do not account for all incidents involving agricultural confined spaces. The early focus on grain-related incidents has resulted in the disproportionate number of these cases included in the database. Furthermore, 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 confined space-related incidents, especially at farms, feedlots and seed processing operations not covered by federal OSHA injury reporting requirements. Based upon earlier research, it is estimated that approximately 30% of cases go unreported or undocumented (Riedel and Field, 2013).

This report provides a summary of the cases documented in 2019 and provides an updated historical perspective, including trends. Specific attention is given to cases involving grain storage and handling facilities, which accounted for most cases, and manure storage and handling operations, the second largest category of incidents. In addition, the report includes a description of the new grain bin safety standards, dealing with out-of-condition grain, brief summary of fires and explosions at grain storage and handling facilities, and observations on current safety training of workers and emergency first responders.

The purposes of publishing these findings on an annual basis are to contribute towards the reduction in the frequency and severity of these incidents by keeping public attention on the problem; assist in developing more effective, evidence-based injury prevention and incident mitigation strategies; and to provide guidance to public policy makers in the development of more effective regulations targeting worker safety and health.

2019 Summary of All Documented Agricultural-Confined Space-Related Cases

In 2019, there were a total of 67 cases documented³, including 38 grain entrapment cases, 8 falls into or from grain storage structures, 5 asphyxiations due to deficient oxygen levels or toxic environments, and 11 equipment entanglements, such as those involving in-floor and sweep augers, that occurred while working inside or around agricultural confined spaces (Figure 2). The number of documented fatal cases (39) was higher than the number of non-fatal cases (28). This discrepancy further suggests an under-reporting of non-fatal incidents.

Grain entrapments accounted for 56.7% of all documented cases during 2019, a lower percentage than the historical average, likely reflecting more aggressive recent efforts to identify other types of agricultural confined-space related incidents, including manure storage.

The total of 67 agricultural confined space cases represented a 9.8% increase (6) from the number of cases documented in 2018, when 61 were recorded (Figure 3). This places the year's total confined space-related cases above the 5-year average of 58 cases per year, but still substantially below the 10-year average (67.1 cases/year). Despite the increased number of cases in 2019, the 5-year running average for all agricultural confined space-related cases continued to decline from its peak of 75.8 cases per year in 2011 to the current 58 cases per year, resulting in the lowest five-year average since 2008. Regardless, the recent uptick in the number of documented cases is a concern considering the media attention being given to the problem.

It should be noted that the five-year average steadily increased from 36.8 cases per year in 2002 to a peak of 75.8 cases per year in 2011, before declining to the current level. Significant contributing factors to the increase in frequency in the early 2000s were better documentation of incidents through more aggressive surveillance efforts and increased access to case information via the internet.

³ Six incidents involved more than two individuals or cases.

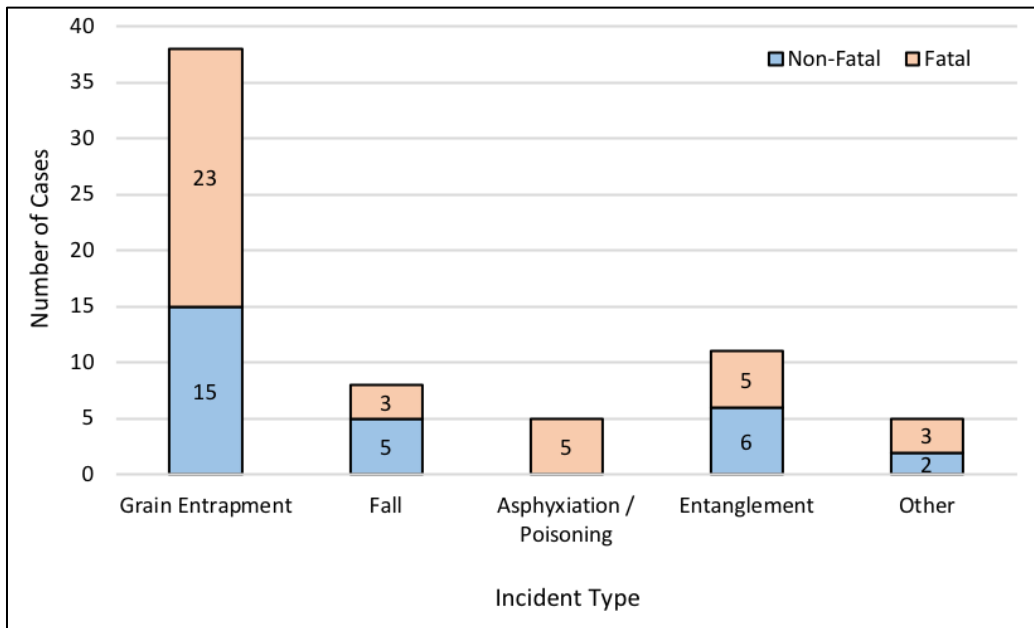


Figure 2: Distribution of all 2019 agricultural confined space-related cases by type of incident, N = 67

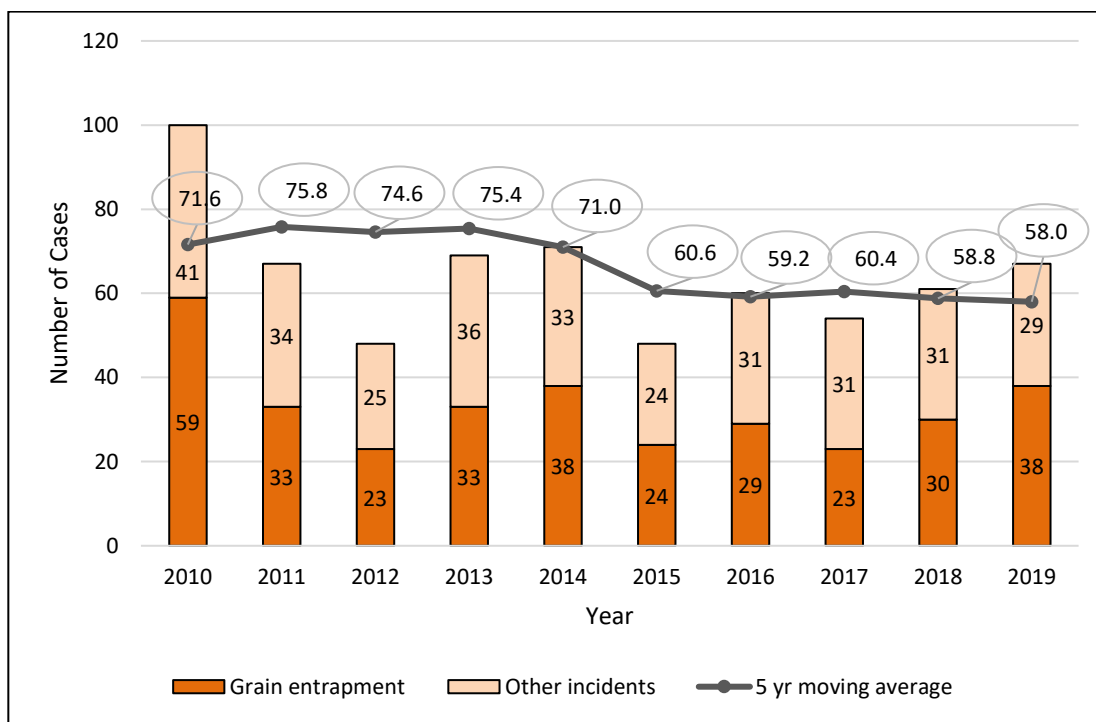


Figure 3: Distribution of annual confined space cases documented between 2010 and 2019

During 2019, the states with the most documented confined space cases of all types, including fatal and non-fatal, were Minnesota (13), Iowa (8), Nebraska (8), Wisconsin (7). There were four cases

documented in Illinois, North Dakota and Ohio. Overall, incidents were documented in 15 states in 2019, substantially less than the 23 states with reported incidents in 2018. Figure 4 illustrates the geographic distribution of all documented cases in the PACSID and those documented in 2019. The three states with the largest number of cases, historically, have been Iowa (253), Indiana (227) and Minnesota (205). As noted in previous summaries⁴, it is estimated that this surveillance effort underreports cases by as much as 30% due to the lack of adequate reporting mechanisms. It is also believed that Indiana has such a high ranking because of more aggressive surveillance efforts over the past 40 years.

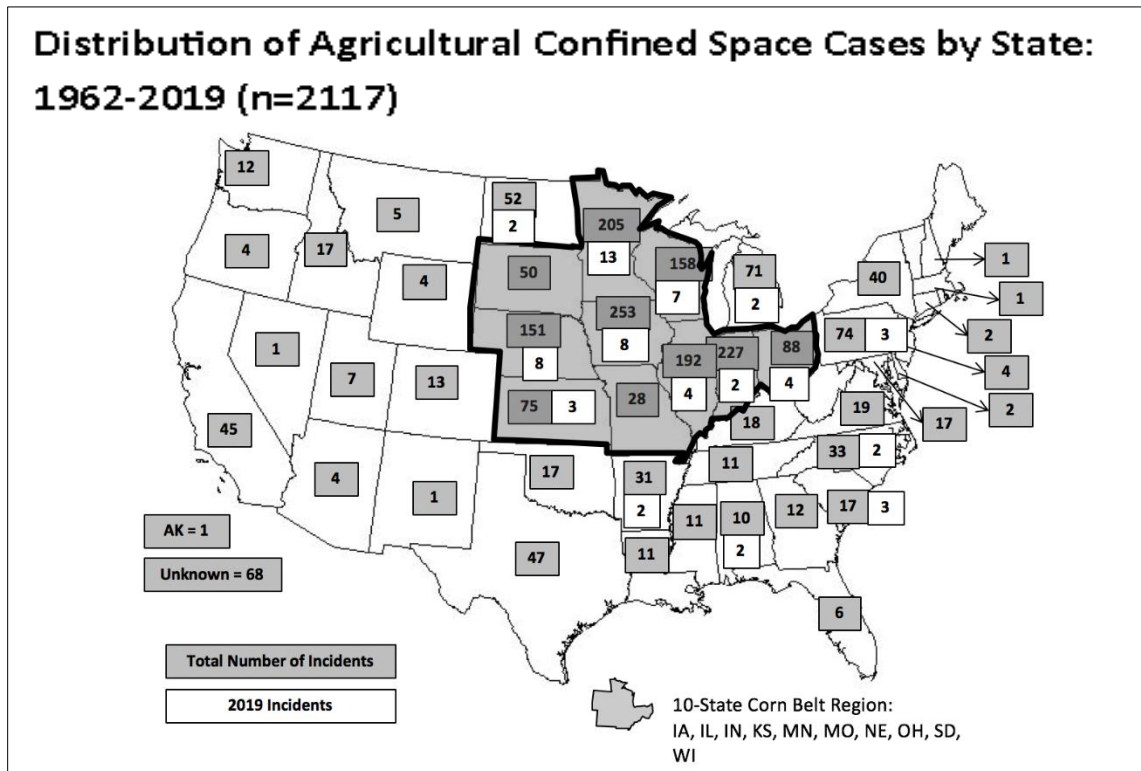


Figure 4: Geographic distribution of all agricultural confined space cases for 2019 and previous years (n=2117).

A specific age was known for 45 of the 67 victims in 2019, with the oldest victim being 82 and the youngest 11 years old. The average age was 48 years old, and the median age 56 (Figure 5). Those over the age of 60 accounted for 16 (35.6%) of the 45 cases (where age was known), reflecting the increasing average age of farmers (58 years old) in the U.S. There were eight cases (17.8%) involving a child or youth under the age of 21, as shown in Figure 5. As noted, a large number of the cases documented (22) did not include the specific age of the victim. There were no female cases documented in 2019.

⁴ See www.agconfinedspaces.org for earlier summaries.

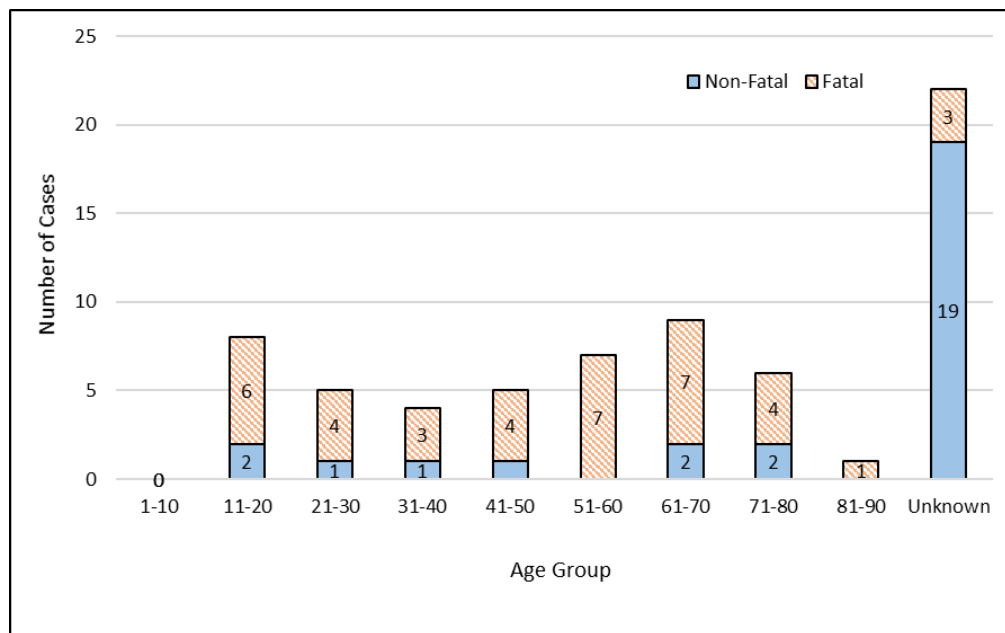


Figure 5: Age distribution of all 2019 agricultural confined space incident victims by number of cases recorded.

In 2019, there were 64 cases where the exemption status⁵ of the facility with respect to OSHA regulations was known. Of those, 49 (77%) occurred on farms or other locations currently exempt from enforcement under the OSHA Grain Handling Facilities Standards (29 CFR 1910.272) or Confined Space Standards (29 CFR 1910.146), with the balance of known cases, 14 (23.3%) taking place at non-exempt commercial grain facilities which is consistent with past trends based on historical data. It is believed that the majority of the cases where OSHA status could not be determined have been OSHA exempt.

A comparison was made between agricultural confined space incidents and mining incidents. Historically, there have been more fatal mining incidents than those occurring in agricultural confined spaces. In 2017, there were 28 fatal mining incidents and 23 fatal agricultural confined space incidents. In 2018, the number of reported fatal incidents in mining (27) equaled the fatal agricultural confined space incidents (27). However, in 2019, the number of reported mining-related fatalities was 24 while the number of fatal agricultural incidents was 39.⁶ In other words incidents involving agricultural confined spaces has replaced mining in the frequency of fatal incidents.

⁵ 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 with confined space entry provisions.

⁶ According to the U.S. Department of Labor’s Mine Safety and Health Administration (MSHA), there were 24 mining fatalities recorded in 2019, which is the lowest number ever documented.

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

Confined space-related cases have occurred in every OSHA region but are mainly condensed in regions 5 and 7 (Figure 6). Region 5 accounted for 44% of all documented agricultural confined space cases (941) with 58% of those cases being grain entrapments, and 13% being falls. Region 7 contains 24% (507) of all cases with grain entrapments, asphyxiation and entanglements representing 66%, 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 (71%).

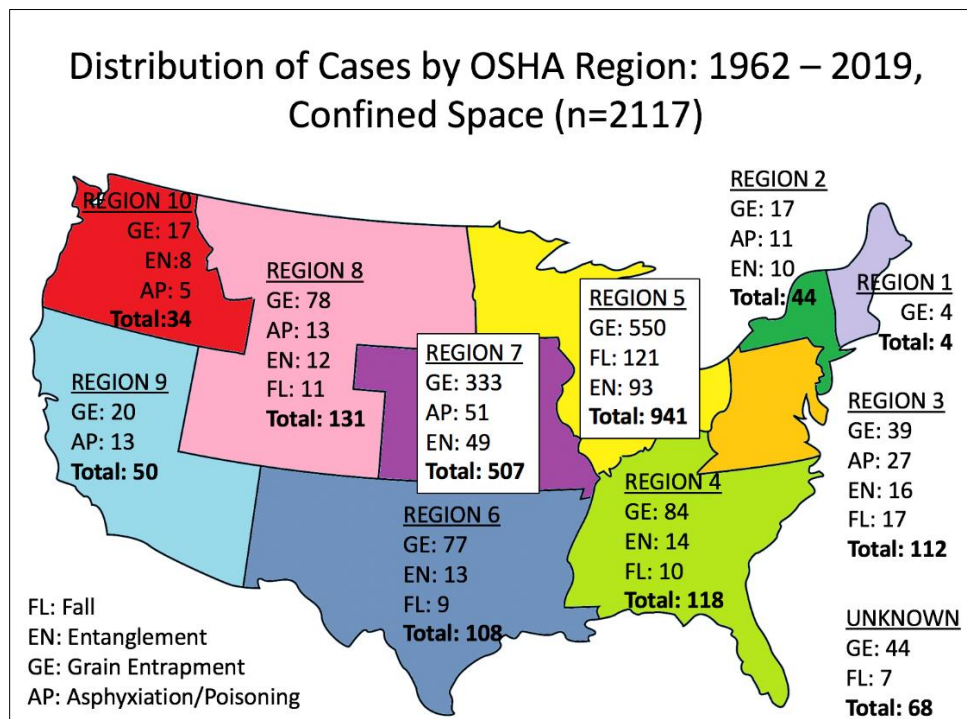


Figure 6: Agricultural confined case distribution by OSHA region from 1962-2019. The total number of cases and most frequent types of cases are listed for each region (n=2117).

Grain Entrapments

The 38 fatal and non-fatal grain entrapment cases⁷ documented in 2019 represented a 26.7% increase from the 30 recorded in 2018. The 38 cases documented in 2019 were substantially higher than

⁷ These cases include only those cases involving entrapment or engulfment in flowing grain. They do not include fatal or non-fatal cases involving falls from grain storage structures or entanglement in grain handling equipment such as in-floor or sweep augers.

the 5-year average (28.8 cases/year) and were the highest of the past four years. Nevertheless, the 5-year running average continues to drop from its peak of 40.4 in 2011 (Figure 7). The number of non-fatal grain entrapment cases (15) was the fifth largest ever recorded after 2010 (27), 2011 (21), 2013 (21), and 2014 (20). Of the total number of reported entrapment cases, 61% resulted in a fatality, a rate higher than the five-year average. In 2019, the state with the most documented grain entrapments - fatal and non-fatal - was Minnesota with seven cases total. This was followed by Iowa, Nebraska and Ohio with four cases. Illinois, North Dakota and Wisconsin had three cases each. Overall, grain entrapments were documented in 14 states in 2019. The majority of grain entrapment cases occurred in the Midwest, or Corn Belt (82%). Historically, 74% of previously documented cases have occurred in the Corn Belt region. Figure 8 provides a geographic distribution of all documented grain entrapment cases contained in the PACSID for which the incident location was known. From a historical perspective, Indiana continues to have the highest number of documented grain entrapment cases. As noted previously, this high number more likely reflects more aggressive surveillance efforts in Indiana to document both fatal and non-fatal grain-related 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 substantially higher number of cases than indicated, based on both total grain production and grain storage capacity.

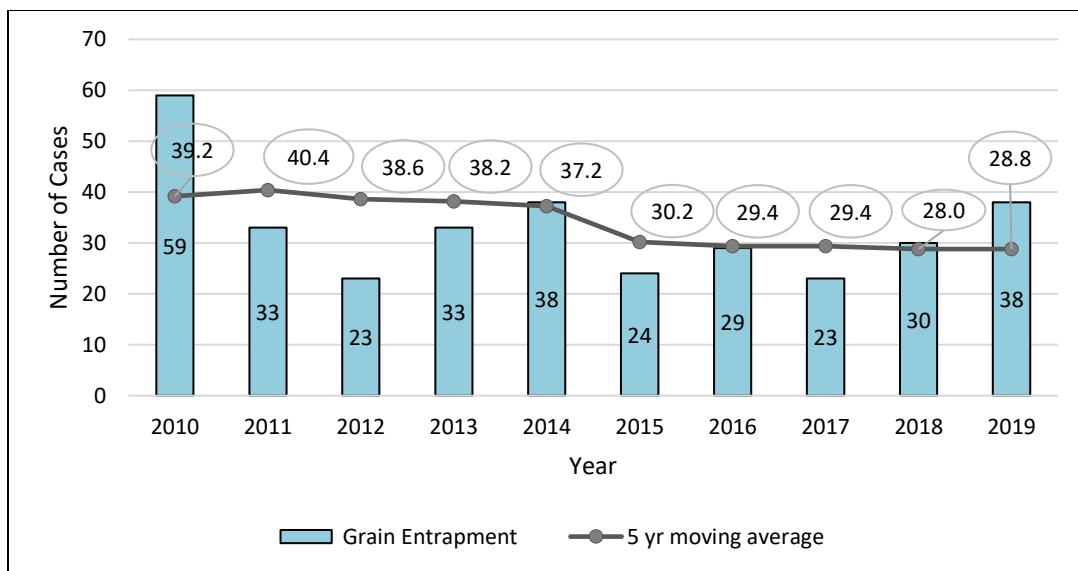


Figure 7: Number of annual grain entrapment cases recorded between 2010 and 2019

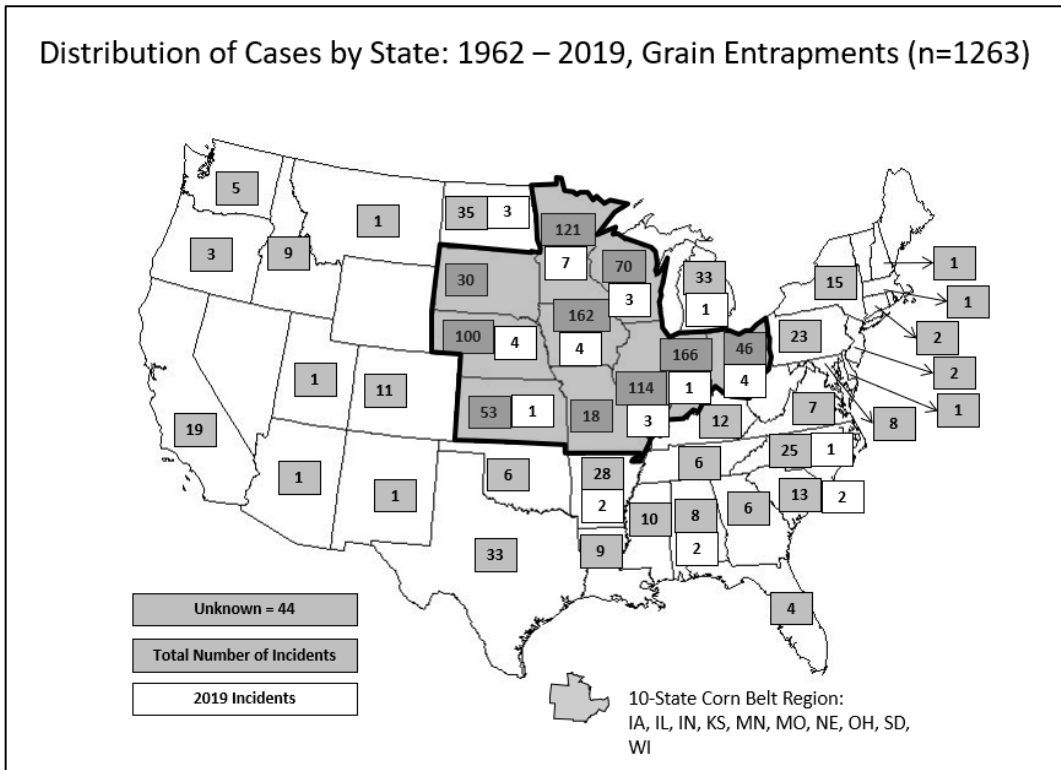


Figure 8: Geographic distribution of grain entrapment cases for 2019 and previous years (n=1263)

All the documented grain entrapment cases in 2019 involved males. There was one 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 of grain entrapment was 80 (figure 9). The average age was 43.4 years old and the median age 49.

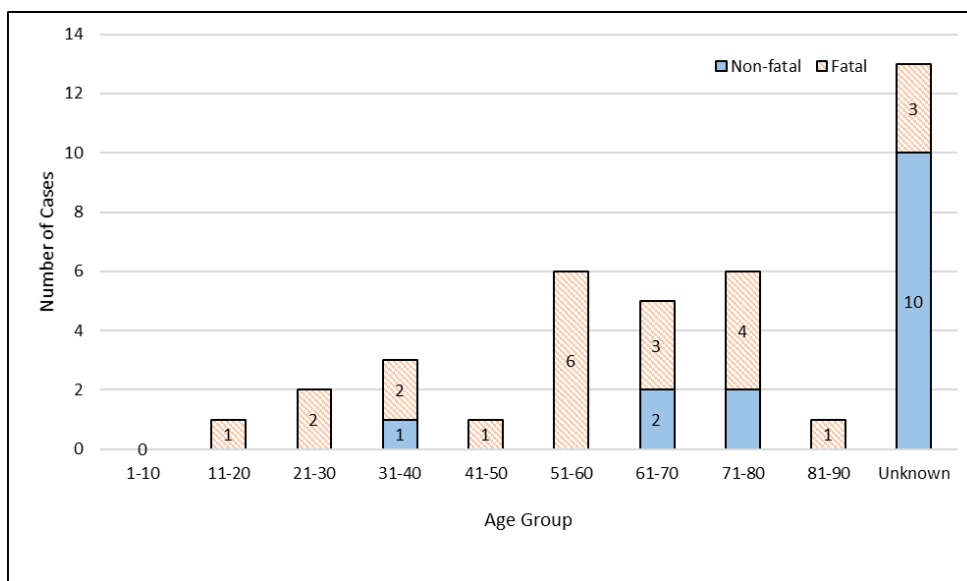


Figure 9: Age distribution of 2019 grain entrapment victims by number of cases recorded

Please note that with over two-thirds of U.S. grain storage capacity currently being on farms which are exempt from OSHA injury reporting requirements, this summary almost certainly does not reflect all grain-related entrapments, fatal or non-fatal, that have occurred.

When Grain Won't Flow

Not since the 2009/2010 growing season have we fielded more questions concerning grain that has gone out-of-condition and won't flow out of storage. When this occurs, the reasons for out-of-condition grain are no longer important. Whether it was insufficient drying of the grain, excess foreign material, or a leaking bin roof - the issue now is grain flow. In some cases, a crusted layer has formed on the surface of the grain or within the grain mass causing a void above the outlets as grain is removed. If the crusted grain then breaks up, the chunks can block the outlets reducing or stopping flow. In other cases, vertically crusted grain can cling to the walls of the structure or form free standing piles that can involve tons of grain that can collapse without warning.

As is well documented in these annual summaries, there is a direct correlation between out-of-condition grain and increased risk of a worker being exposed to an entrapment situation. In other words, when a farmer or elevator employee has to "fight" to get the grain to flow out of the structure, there is a strong temptation to by-pass safe work practices and enter the structure in order to make attempts to keep the grain flowing.

If the grain won't flow, it's already too late to debate what was or was not done last fall to cause the problem. The issue at hand is to remove the grain without putting anyone at risk of entrapment. The

following are some steps to consider. They may not be the most profitable options, but are intended to keep everyone safe.

1. Never enter a bin where there is evidence of crusting on the surface or within the grain mass. If grain is removed from the structure and the surface has not flowed inward – stay out! This is a clear sign that crusting is present and a void has formed over the outlet.
2. If there are any signs that the grain is or has gone out-of-condition, it needs to be removed immediately. The condition of the grain will not improve if left in storage, and will only become worse. As warm weather arrives, biological and insect activity will increase, leading to even more spoilage.
3. Perform all observations or unplugging effort from outside the bin, at the top access hatch. Again, if there is evidence of crusting, spoilage, or excessing heating – stay out! The risk is too great. In some cases, long pipes, rebar, or other probes can be inserted into the grain mass to break up crusted grain or trash that is plugging the outlet. Watch out for overhead power lines when handling these long probes.
4. If the grain has become so crusted that it cannot be removed according to the bin manufacturer’s recommendations, contact a professional grain salvage service that has the experience and equipment to break up and remove out-of-condition grain. These services are not inexpensive, but can save lives.
5. Do not cut open the side walls of a bin without consulting the manufacturer. Cutting into a bin could damage the structural integrity of the bin, or result in uneven unloading that could cause the structure to fail and collapse.

Using Children and Youth in Grain Safety/Rescue Training Activities

Even after an effort to discourage the practice (Field, 2018), ongoing surveillance efforts continue to identify cases in which children and youth are being used as live “victims” in safety demonstrations, grain rescue training, or recreational/educational activities. (This has included, in the past, two male victims, age 6 and 13, who asphyxiated in free flowing grain during an educational visit to a farm.) In addition, online images continue to document cases in which children and youth are being deeply entrapped in grain, up to their shoulders, to demonstrate the effects of entrapment and to conduct extrication training for emergency first responders. This practice is more widespread than originally believed, with literally hundreds of online 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

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, youth, and others uninformed regarding the hazards of flowing grain, as “victims” in flowing grain safety 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. An additional concern that should be considered is the risk of being held liable if an injury were to occur. 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.

2019 Summary of Grain Dust Related Explosions

In 2019, there were eight grain dust explosions reported in the U.S. This compares to 12 in 2018 and a ten-year average of 8.4 explosions. There were one fatality and four injuries. The explosions were in two feed mills, one ethanol plant, one grain mill, and four grain elevators. The probable ignition sources were identified in two cases as fires, one as static electricity, one as hot bearing, and four unknowns. Fuel sources were identified as four from grain dust and four unknowns. The explosions occurred in seven different states: three in Iowa and one each in Indiana, Illinois, Minnesota, Ohio, and Georgia. No incidents involving injuries were reported as occurring on farms.

Adoption of ASABE Grain Bin Safety Standard

After years of deliberation the American Society of Agricultural and Biological Engineers (ASABE) published a voluntary standard that provides design recommendations to reduce the risk of grain entrapment in new steel grain storage bins and tanks. The standard, identified as ANSI/ASABE S624,

Grain Bin Access Design Safety provides recommendations for safe bin access, anchor attachment points for lifelines, and a uniform safety decal (See Figure 10).

The standard only applies to new structures and is intended to not only provide a safer structure, but increase the awareness of the hazards that exist in and around these structures.

The new standard is a voluntary standard that does not carry the force of law nor will it be enforced by the Occupational Safety and Health Administration (OSHA). However, the standard is a significant step towards bringing standardization to the design of grain storage structures found on farms across the U.S. For example, one key provision is the requirement that all new structures be designed so that all powered and non-powered equipment used to move grain can be locked out and tagged for safe bin entry. Adequate, labeled anchor points that have the capacity to safely secure lifelines are also addressed in the standard.

For additional information on the standard contact ASABE headquarters at asabe.org/OrderPubs.



Figure 10: ASABE safety decal for grain bin access points

2019 Summary of Manure Storage, Handling, Transport Equipment and Facility Incidents

Through the ongoing surveillance of fatalities and injuries involving agricultural confined spaces, no fewer than 369 fatal and non-fatal cases relating to manure storage, handling and transport equipment,

and facilities have been documented over the past 40 years. Most of these cases were documented relatively recently due to enhanced or more aggressive surveillance efforts that were initiated with support from an OSHA Susan Harwood Training Grant. During 2019, 19 U.S. incidents involving 28 victims were documented. Of these cases, 4 (14.3%) were fatal. A higher than expected portion, 75%, involved manure transport vehicles such as tankers and spreaders. The average victim age, if known, was 40 years. There were 5 cases (18%) involving children, youth, and beginning workers under the age of 21 years old, which closely aligns to the historical pattern of nearly 20% of all agricultural confined space-related incidents involved children and youth under the age of 21.

In 2019, the state with the most documented manure cases, fatal and non-fatal, was New York with 10 cases total (35.7%). This was followed by Minnesota (4), Iowa (3), California (3), and Michigan and Pennsylvania with two cases each. Illinois, Ohio, Wisconsin, and Maine had one case each. Overall, manure incidents were documented in 10 states in 2019. The distribution of agent, facility, or equipment of injury involved in 2019 was as follows: 4 cases involved falling in manure pits of which 3 were fatal, 20 cases involving manure handling equipment, including skid steer loaders, the most frequently identified agent, and 4 cases involved manure transport equipment, transfer pumps, and liquid transport tankers.

As with all agricultural confined space incidents, especially those occurring at OSHA exempt agricultural worksites, providing a comprehensive summary of injuries and fatalities is simply not possible due to the lack of a universal reporting mechanism.

Project Website

With support from a Susan Harwood Grant from the U.S. Department of Labor, the website (www.agconfinedspaces.org) was developed to provide resources for those conducting safety and health training in the area of agricultural confined spaces, with an emphasis on grain storage and handling hazards. Training material, frequently asked questions, past summaries of injuries and fatalities and an extensive list of resources can be found at the site. In 2019 the site hosted over 10,047 visitors.

One of the most frequently visited resources on the website is the curriculum developed for young and beginning workers in the grain industry (**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 4750 youth in secondary school agricultural education programs, informal, out-of-

school settings, and college level agriculture classrooms. 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.

Another education resource at the site is designed for use in training emergency first responders to safely and effectively respond to incidents at grain storage and handling facilities. Over the past seven years over 4600 emergency first responders have participated in training using this first responder material. This curriculum is also available as a free download.

New Educational Resources

In 2018, Purdue's Agricultural Safety and Health Program collaborated with the Posey County Farm Bureau to produce STOP – THINK – LIVE, a video that re-enacts the actual grain bin entrapment of a Posey County, Indiana farmer. Copies were distributed to over 450 County Farm Bureau presidents, each secondary agriculture education teacher, every County Extension office, and many first responder agencies. The video includes interviews with the farmer, shows the rescue strategies used, and has short outtakes of the role of out-of-condition grain and the risk of entrapment in grain transport vehicles. Copies can be ordered for \$10.00 from:

Posey County Farm Bureau
PO Box 189
30 West Main Street,
Poseyville, IN 47633-0189

A new feature film was released in 2019 that tells how a grain entrapment can impact an entire community. This high-quality production is available, for a fee, to be shown at local events. For more information visit silotheilm.com. Special pricing is available to FFA Chapters.

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.

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- 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.
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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/>