

# 2014 Summary of U.S. Agricultural Confined Space-Related Injuries and Fatalities

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## Introduction<sup>1</sup>

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As part of an effort to gain a better understanding of grain-related entrapments<sup>2</sup> and engulfments, Purdue's Agricultural Safety and Health Program has published, over the last decade, an annual summary of these incidents<sup>3</sup> ([www.agconfinedspaces.org](http://www.agconfinedspaces.org)). These summaries are based on data gathered, documented and entered into Purdue's Agricultural Confined Space Incident Database (PACSID). With support from the U.S. Department of Labor's Susan Harwood Training Program, over the past four years, the surveillance effort was expanded to include not only incidents of entrapments in grain, but also asphyxiations, entanglements, falls, fires and electrocutions in and around all forms of agricultural confined spaces.<sup>4</sup> This annual summary for 2014 continues to reflect this expanded effort and hopefully adds additional light on a problem that poses significant risk to agricultural workers.

As the result of using the broader definition for agricultural confined spaces to identify cases of interest, no fewer than 70 cases were documented in 2014. Of these, approximately 54% were directly related to grain entrapments. To ensure continuity of the data record involving entrapments in grain and other free flowing agricultural material, and due to the high percentage of past fatal cases involving grain entrapment, special attention continues to be given to these incidents.

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<sup>1</sup>Partial support for this material was provided under grant number SH24885SH3 from the Occupational Safety and Health Administration, U.S. Department of Labor. It does not necessarily reflect the views or policies of the U.S. Department of Labor, nor does mention of trade names, commercial products, or organizations imply endorsements by the U.S. Government.

<sup>2</sup>Flowing grain entrapments include both fatal engulfments and partial entrapments that require assistance in order for the victim to be extricated.

<sup>3</sup>An incident may involve multiple victims that are recorded in the database as individual cases.

<sup>4</sup>The definition used to identify an agricultural confined space in this study is: Any space found in an agricultural workplace that was not designed or intended as a regular workstation, has limited or restricted means of entry or exit, and has associated with it potential physical and/or toxic hazards to workers who intentionally or unintentionally enter the space.

In addition to the cases documented in 2014, approximately 50 cases that occurred in previous years were added to the database due to ongoing discovery efforts. Also, 11 cases were removed from the database as they, upon further investigation, no longer met the criteria for having occurred in an agricultural confined space, or occurred outside the U.S. The total number of cases documented to date and entered in the PACSID is 1760. The identification of additional cases can be attributed to the increased surveillance efforts allowed by the support from the U.S. Department of Labor as well as increased public awareness of the problem leading to greater media exposure and voluntary reporting.

As noted in past summaries, the data presented do not account for all incidents involving agricultural confined spaces. There continues to be no comprehensive or mandatory incident/injury reporting systems for most of agriculture, and there is reluctance on the part of some victims and employers to report non-fatal incidents, even where extrication was required, and therefore no public record is available. Based upon prior research, it is estimated that the documented annual cases represent approximately 70% of the total cases that actually occur annually in the Corn Belt.

## **2014 Summary of All Agricultural-Confined Space-Related Cases with Comparisons to Previous Years**

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In 2014, there were no fewer than 38 grain entrapment cases, 12 falls, 8 equipment entanglements (including augers), 9 fire related injuries and 3 asphyxiations that were identified as occurring in an agricultural confined space (Figure 1). Grain entrapments accounted for 54% of the documented cases. For incident types with more than one case, asphyxiations constituted the most dangerous with a reported 67% fatality rate, while grain entrapments ranked fourth with a 45% fatality rate. Again, it is believed that most confined space incidents are under-reported especially those resulting in non-fatal grain entrapment and involving being overcome by exposure to toxic environments.

The 70 confined space cases represent a 4% increase in number of cases from 2013 when 67 cases were recorded. The previous three years (2010, and 2011, 2012) experienced 100, 64 and 46 documented cases respectively (Figure 2). The five-year average continues at a relatively high level of 69.4, slightly below the peak of 74.8 in 2011. Since 2002, the five-year average has increased steadily from 36.8 cases per year to an average of 52.6 cases per year in 2008, 61.2 in 2009, and 70.8 in 2010, and peaking in 2011 with 74.8 cases.

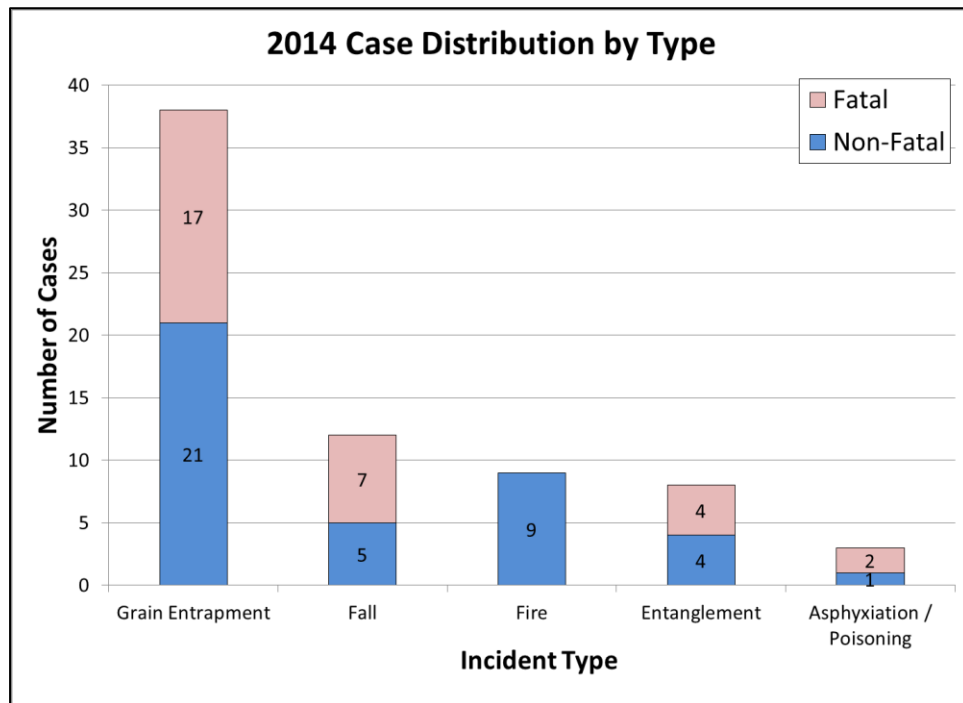


Figure 1: Distribution of 2014 agricultural confined space-related cases by type of incident.

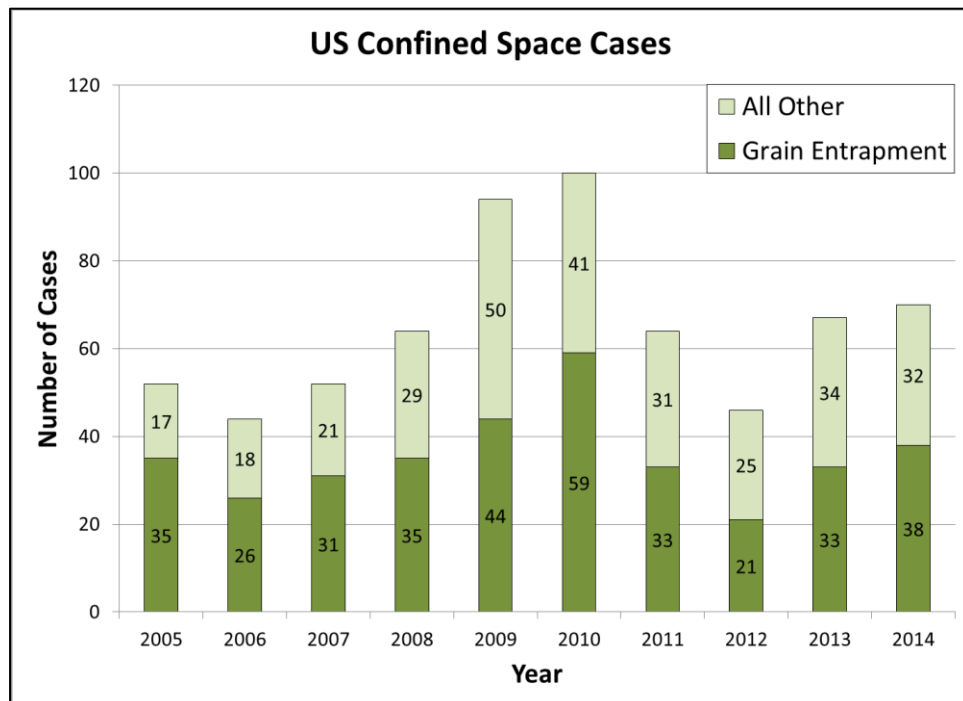


Figure 2: Number of annual confined space cases recorded between 2005 and 2014.

In 2014, the states with the most documented confined space cases, of all types, including fatal and non-fatal, were Minnesota (9) and Ohio (9). Seven of Ohio cases involved one incident in which a fire injured seven workers while attempting to extinguish a fire inside a grain storage structure. There were five cases each for Indiana, Nebraska, Illinois, and Wisconsin. There were four cases each for Michigan, Iowa and Pennsylvania. Overall, incidents were documented in 20 states in 2014, three states less than 2013. Figure 3 provides a geographic distribution of all documented cases in the PACSID, where the location was known, and the sites, where known, for 2014.

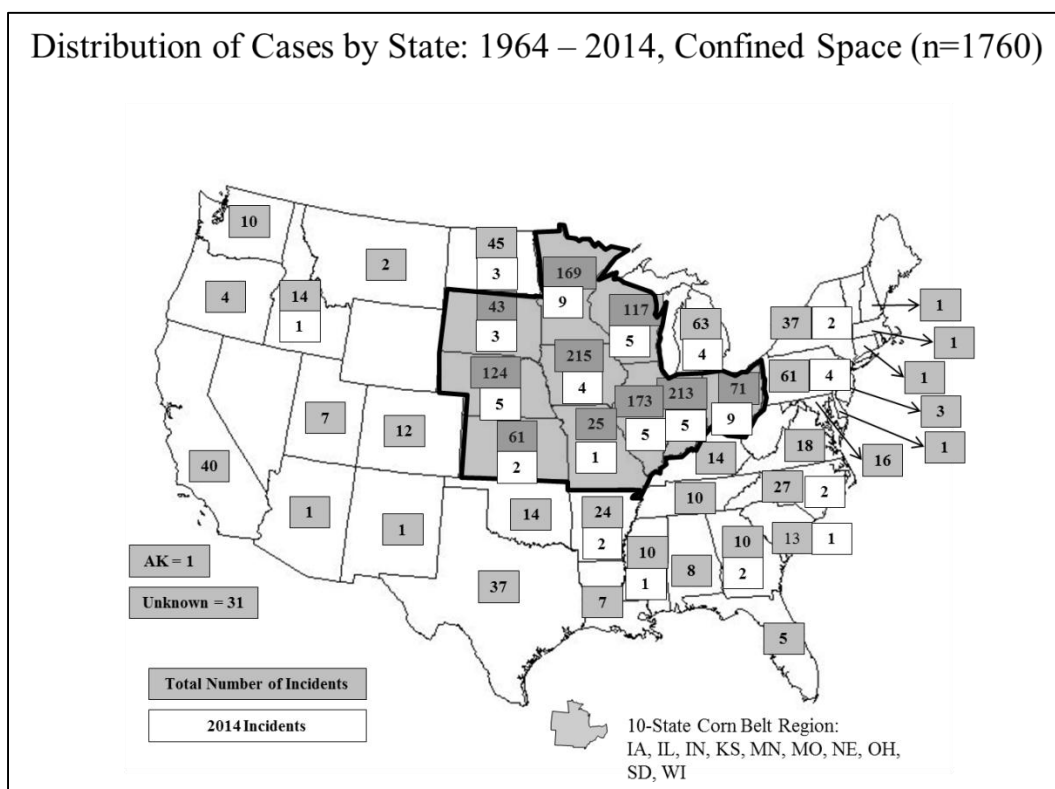


Figure 3: Geographic distribution of confined space cases for 2014 and previous years.

There was only one case in 2014 involving a female. Also, there were six cases involving a child or youth under the age of 20, as shown in Figure 4. Overall, a specific age was known for 46 of the 70 victims in 2014, with the oldest victim being 81, and the youngest 5 years old. The average age was 45 years old, and the median age 51.5 (Figure 4). As can be noted, a large number of the cases documented did not include a specific age of the victim.

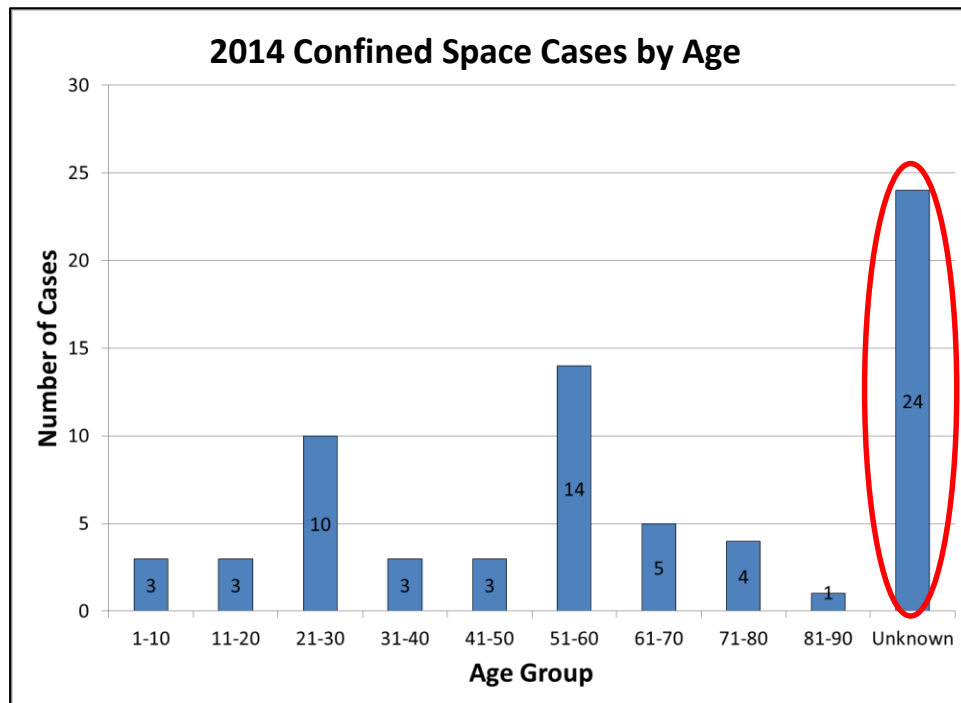


Figure 4: Age distribution of 2014 agricultural confined space victims by number of cases recorded.

## 2014 Summary of Grain Entrapments with Comparisons to Previous Years

The 38 grain entrapment cases represent a 15% increase in entrapments from 2013 when 33 entrapments were recorded. The previous three years (2010, and 2011, 2012) experienced 59, and 32 and 21 documented cases respectively. The five-year average continues at a relatively high level of 36.8, below the peak of 40.4 in 2011 (Figure 6). In 2014, the state with the most documented grain entrapments, fatal and non-fatal, was Minnesota (6). There were four cases each for Indiana and Iowa, and three cases each for North Dakota, Wisconsin, Nebraska, South Dakota, and Illinois. Overall, entrapments were documented in 16 states in 2014. The majority of grain entrapment cases occurred in the Midwest (87%) in contrast with last year in which only 61% of the cases occurred in the Midwest. Figure 5 provides a geographic distribution of all documented grain entrapment cases contained in the PACSID where the location was known.

# Distribution of Cases by State: 1964 – 2014, Grain Entrapments (n=1096)

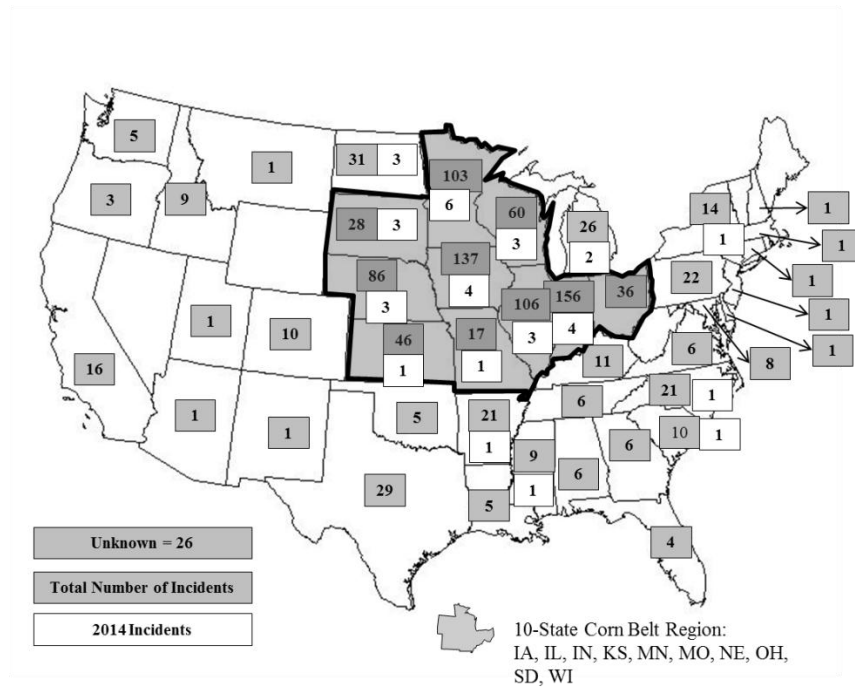


Figure 5: Geographic distribution of grain entrapment cases for 2014 and previous years.

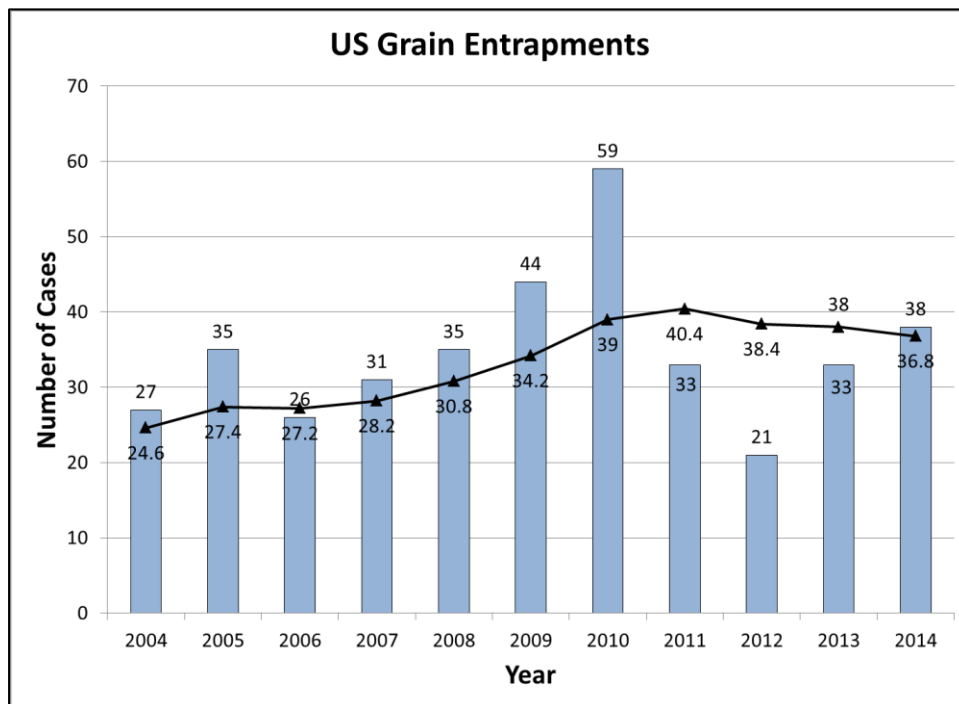


Figure 6: Number of annual grain entrapment cases recorded between 2004 and 2014.

In 2014, there were 36 cases where the exemption status<sup>5</sup> of the facility with respect to OSHA regulations was known. Of those, 31 (82%) occurred on farms or other locations currently exempt from the OSHA Grain Handling Facilities Standards (29 CFR 1910.272), with the balance of 5 (13%) taking place at non-exempt commercial grain facilities. This is in strong contrast to 2013 and 2012 when 70% and 35% of all cases occurred on exempt farms. It is important to note that there were only 2 unknown cases this year and it is believed that the majority of the unknown cases, based on historical data, have OSHA exempt status.

All documented victims were male except for one case. Also, there were 4 documented cases involving a youth under the age of 20 in contrast to 2013 in which there were no child/young adult cases (Figure 7). Overall, a specific age was known for 26 of the 38 victims in 2013, with the oldest victim being 81, and the youngest 8 years old. The average age was 49 years old, and the median age 53. In contrast to previous years, three of the grain entrapments occurred in grain transport vehicles. The last time a grain entrapment in a grain transport vehicle was documented was in 2011.

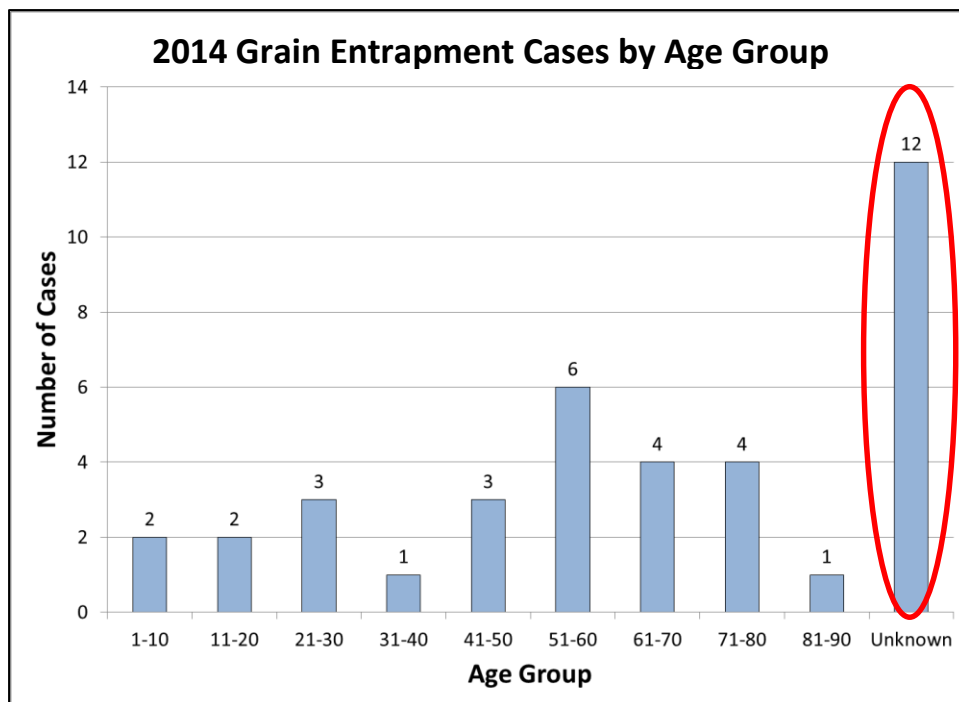


Figure 7: Age distribution of 2014 grain entrapment victims by number of cases recorded.

<sup>5</sup> 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.

During 2014, the primary medium of entrapment, when identified, was corn (19 cases, 50%). Soybeans were the second most common grain with four cases (11%). Unlike previous years the ratio of fatal to non-fatal cases actually rose to 45% in comparison to last year's 39%. This number is still relatively low in comparison to 1964-2008, during which 73% of documented entrapments resulted in a fatality. 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.

## Summary of Documented Falls In and Around Agricultural Confined Spaces

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Falls in and around agricultural confined spaces represent the third largest group of confined space-related cases after grain entrapments with a total of 180 cases documented to date. However, documented cases for falls have only been continuously recorded since 1990 (177 cases recorded; 13% of all cases). When comparing other categories over the same timeframe, falls are the second highest injury type after grain entrapments. It is believed that the majority of non-fatal falls involving agricultural confined spaces go unreported (Figure 8).

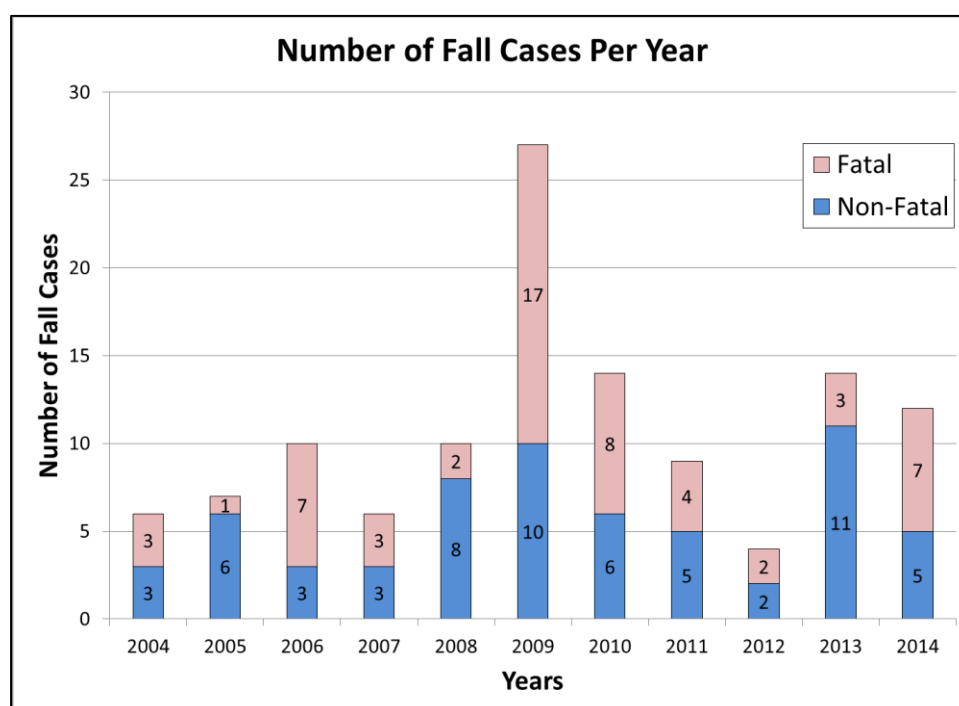


Figure 8: Number of annual fall cases recorded between 2004 and 2014.



## Summary of All Documented Agricultural Confined Space-Related Cases By Agent, Location, and Exemption Status

Figure 9 compares all documented cases currently documented in the PACSID with respect to type of agricultural confined space. As can be seen, those cases involving the storage, handling, and transport of grain and grain by-products account for the overwhelming majority of documented confined space-related cases, with over 1,300. The majority of these cases involved entrapment or engulfment in free flowing agricultural materials, primarily grain. It is known that due to less aggressive surveillance efforts, incidents involving manure storage and forage silos are significantly under-reported. Also under-reported are incidents involving entanglements and falls during the earlier years before the expanded surveillance effort began.

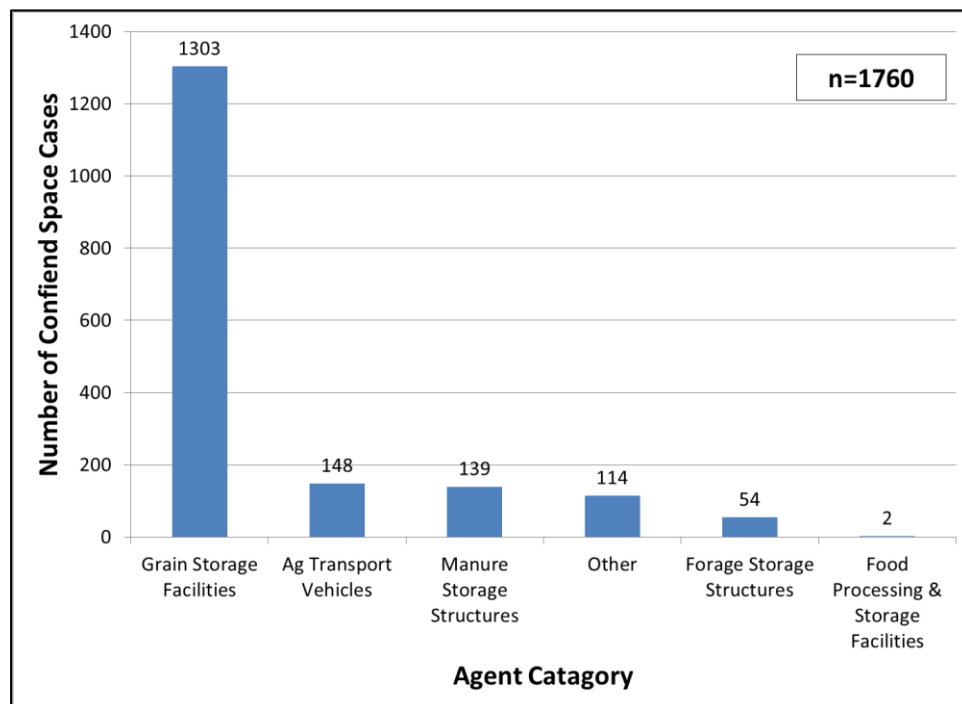


Figure 9: Agricultural confined space-related cases documented between 1962-2014 based on agent category.

The Midwest continues to represent the majority of all grain entrapment cases (76%) and the South comes a distant second at 14%. The majority of the cases in the Midwestern and Eastern regions are OSHA exempt cases (Figure 10). The South and West regions have more non-exempt cases.

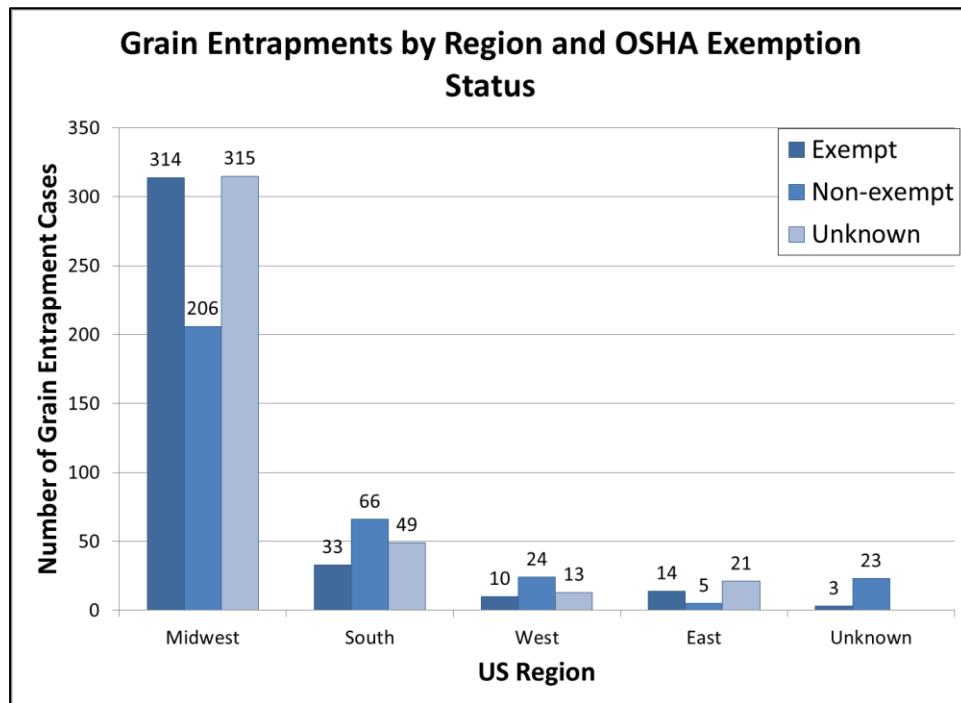


Figure 10: Grain entrapment cases documented between 1962-2014 based on region and OSHA exemption status.

## Overview of Recent Publications

Part of the continued efforts of surveillance of confined space incidents is the publication of relevant research articles that summarized and analyzed cases documented in the PACSID database. This effort has led to multiple publications such as Freeman et al. (1998), Kingman et al, (2001), Roberts et al. (2011) and Riedel et al. (2013). Below are summaries of two recent research publications based on the PACSID database.

## Young and Beginning Workers

At the time the PACSID database was analyzed for the youth summary it contained 1654 confined space cases of which 1028 were grain entrapment cases. Of these, 246 cases (24% of all grain entrapment cases) occurred to young and beginning workers (under age of 21). The grain entrapment cases are nearly equally distributed across age groups (1-80 years old) with a 70% fatality rate, with the exception of the cases involving the 11-20 age group, which accounted for

almost 18% with an 80% fatality rate (Figure 11)<sup>6</sup>. The majority of the cases for those aged between 1 to 20 reveals that the majority of the cases (86%) for ages 2 to 16 occurred at exempt facilities, while the majority (65%) of the cases for ages 17-20 occurred at non-exempt facilities (Figure 12). While only 120 (12%) grain entrapment cases involved grain transport vehicles, these cases account for 38% (94 cases) of all young and beginning workers. Indeed, if only grain transport vehicle cases are considered, 78% of all cases occurred to young and beginning workers (Figure 13).

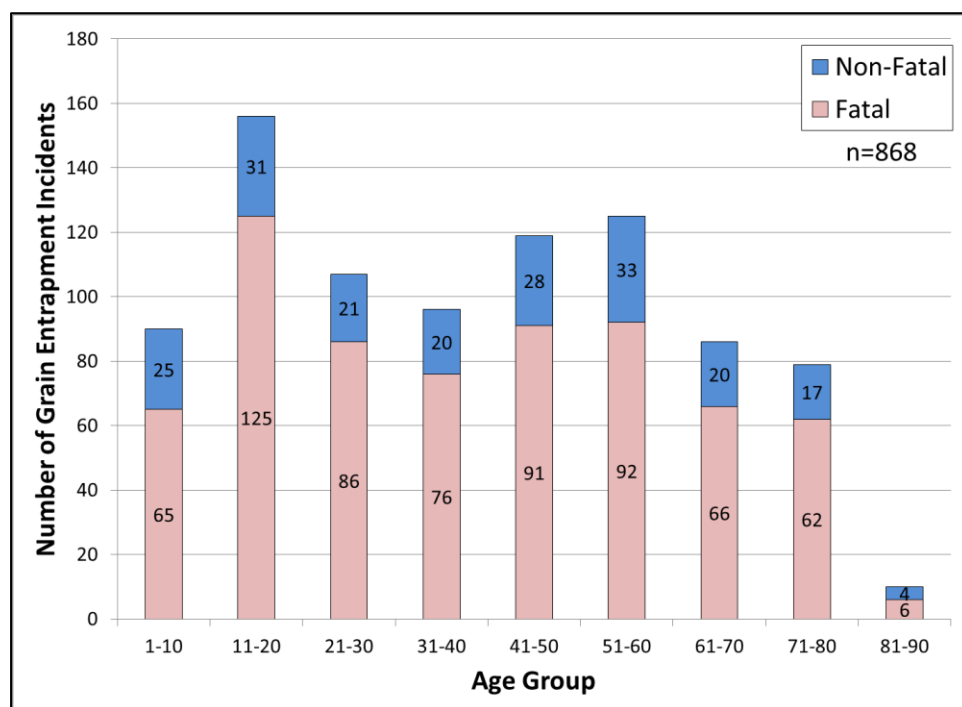


Figure 11: Age distribution of documented grain entrapments from years 1964 to 2013.

<sup>6</sup> Only the cases where age was known are listed. The exact age of the person was unknown for an additional 160 cases and these cases represent 34 fatalities and 126 non-fatalities.

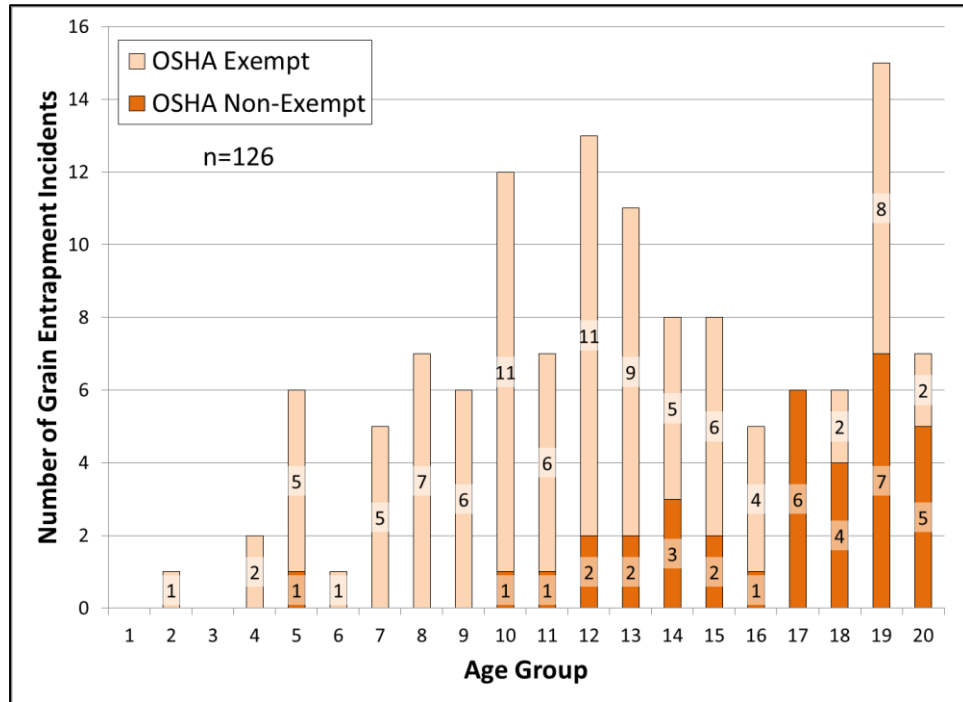


Figure 12: Age distribution of grain entrapments by exempt vs. non-exempt operation from years 1964 to 2013, ages 1-20.

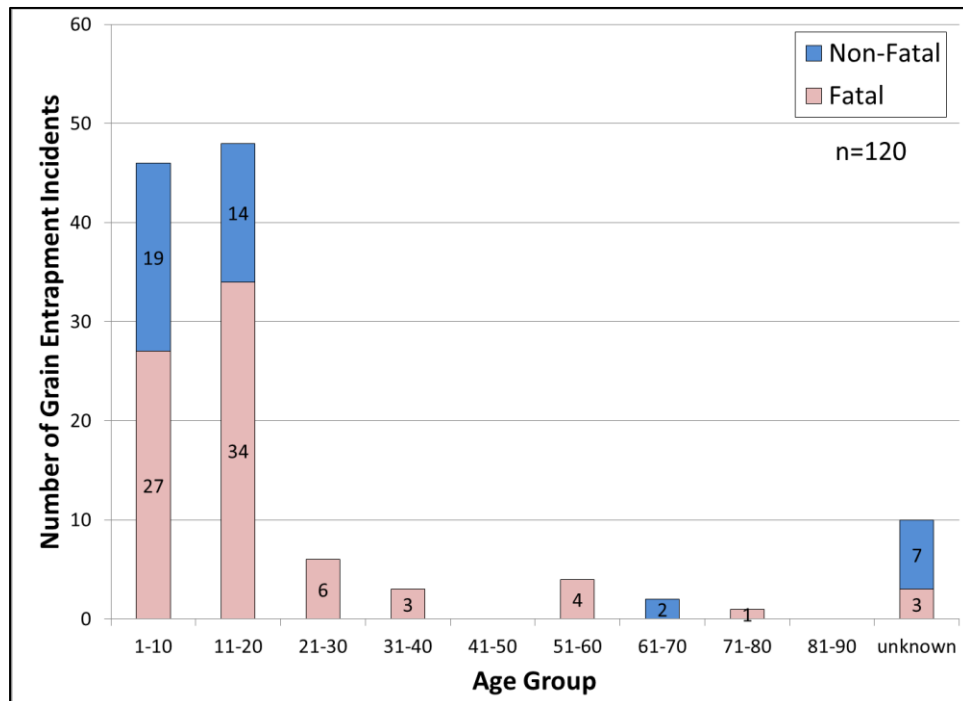


Figure 13: Age distribution of grain entrapments from years 1964 to 2013 involving grain transport vehicles.

## Grain Vacuums

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Over the past two decades, there has been more widespread use of pneumatic handling of grain at commercial grain storage facilities and on farms as these operations have increased grain storage capacity and handle larger volumes of grain and feed. In some cases, manufacturers have suggested that the use of these systems is a safer alternative to removing residual grain manually in conjunction with the use of sweep augers. The use of grain vacuum systems has also been increasingly documented as a strategy in responding to grain storage fires and human entrapment and engulfment in flowing grain. With greater utilization of these machines have come reports of entrapments and engulfments. An article was prepared that summarizes 27 such documented cases, including 21 fatalities that resulted from the use of portable grain vacuum systems. It includes specific recommendations for engineering, educational, and regulatory strategies to reduce the risks associated with the use of these systems. (Field, Heber, Riedel, Wettschurack, Roberts, & Grafft, 2014). A copy of this paper can be found at the following website: [www.agconfinedspaces.org](http://www.agconfinedspaces.org) under the Publications Section.

## Determination of Entrapment Victim Extrication Forces

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The forces required to extricate a test mannequin from a grain mass when buried at different depths with and without a grain restraint system were determined. When there was no grain restraint system in place, the vertical force required to pull the mannequin from the grain when it was buried waist deep and to the underarms was 1259 and 1766 N (283 and 397 lbs.), respectively. It increased to 1584 N (356 lbs.) (+26%) and 2153 N (484 lbs.) (+22%), respectively, with the restraint in place due to the changes in grain properties brought about by the insertion of the rescue tube. It was concluded that the use of a grain restraint during extrication of a victim does not reduce the forces required and that forcefully pulling an entrapped victim, especially with mechanical assistance, with or without a grain restraint system could result in severe injuries and possible death due to the forces exerted on the victim. The authors recommend that these findings be incorporated into current grain extrication training for emergency responders.

This article was published in the Journal of Agricultural Safety and Health, Vol. 21(2), 2015.

## New Website

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As part of the plan of work for the U.S. Department of Labor's Susan Harwood Grant, a new website on agricultural confined spaces has been developed and is currently accessible ([www.agconfinedspaces.org](http://www.agconfinedspaces.org)). This website is intended to be a resource for those conducting safety and health training in the area of agricultural confined spaces with a special focus on grain storage handling, and processing. Training resources are provided that are relevant to farm operators, youth and beginning workers, current workers in the commercial grain industry, and emergency first responders. The site includes an extensive bibliography of resources, frequently asked questions, and related links.

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

- [www.agconfinedspaces.org](http://www.agconfinedspaces.org)
- [www.grainsafety.org](http://www.grainsafety.org)
- [www.grainsafety.us](http://www.grainsafety.us)
- [www.grainentrapmentprevention.com](http://www.grainentrapmentprevention.com)
- <http://apps.npr.org/buried-in-grain/>

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