# Estimating the Effect of Selected Predictors on Agricultural Confined-Space Hazard Perceptions of Utah Farm Owner/Operators

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**ABSTRACT.** *The purpose of this study was to assess how selected variables affect the confined-space hazard perceptions of farmers in Utah. A confined space was defined as "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 contains potential physical and toxic hazards to workers who intentionally or unintentionally enter the space" (proposed by NCERA-197, 18 May 2011, draft copy). A total of 303 out of 327 farm owner/operators provided complete surveys that were used in the analysis. The state of Utah was grouped into five regions in this study: central, east, northeast, northwest, and southwest. Grain and dairy production comprised 48.7% of the operations responding to the survey. The general linear modeling (GLM) procedure in SAS 9.3 was used to select the models on hazard perception scores for the five studied regions. Interested predictors included response type, production type, safety planning, and injury concerns. Animal production operations had the highest average number of confined spaces ($\mu$ = 4, SD = 2.7). Regionally, the northwest region had the highest average number of confined spaces ($\mu$ = 4, SD = 2.5). The variables contributing most to confined-space hazard perceptions were injury and death concerns while working alone in confined spaces. Three factors were generated using principle factor analysis (PFA) with orthogonal varimax rotation. Results suggested that factors affect hazard perceptions differently by region. We conclude that outreach and educational efforts to change safety behaviors regarding confined-space hazards should be strategically targeted for each region based on predicting factors. The result can assist agricultural safety and health professionals in targeting agricultural producers' social networks to address human factors such as worker attitudes and/or lack of skills or knowledge that effect hazard perceptions of confined spaces in agriculture.*

**Keywords.** *Confined spaces, Education, Farm owner/operators, Injury risks, Safety.*

In production agriculture, confined spaces such as grain storage bins, grain transport vehicles, manure storage facilities, and silos present numerous health and safety hazards to farmers and ranchers, their families, and their employees (NCERA-197, 2011; Riedel and Field, 2011). Under OSHA Regulation 1910.146(b), a confined space means that the space is large enough to allow an individual to enter and perform assigned work with limited or restricted means for entry or exit and is not designed for continuous occu-

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pancy (OSHA, 2011). Two of the most commonly documented agricultural confined spaces are grain bins and manure storage facilities. Between 1964 and 2010, nearly 900 fatal and non-fatal grain entrapment cases in the U.S. have been documented by Purdue University's Confined Spaces Database (Riedel and Field, 2011), and 77 fatal incidents have been documented for livestock waste handling and storage operations between 1975 and 2004 (Beaver and Field, 2007). Of the 77 fatality cases related to manure storage, 17 (22%) were individuals who were attempting to rescue the original victim within the manure storage facility. Riedel and Field (2011) documented that 72 fatality cases occurred on or inside forage storage structures between 1964 and 2010. Beaver and Field (2007) documented that operators and workers working around manure handling and storage facilities knew that these facilities were unsafe yet failed to follow basic recommended work practices, such as those found in ASABE Standard EP-470 (*ASABE Standards*, 2005). In the intermountain west, large dairy operations have numerous sources where a potential confined-space injury or fatality incident can occur. These sources include manure storage systems, feed concentrate storage bins, and silage storage facilities (Sinnard, 1952; Johnston and Hawton, 2008; Radunz, 2010).

Managers often react to potential hazards by using safety training, especially to reduce workers compensation claims (Rubinsky and Smith, 1973; Morgenstern, 1992; Chadd, 1994; McLain, 1995). Many agricultural employees and family members have not receive such training due to certain exemptions under OHSA regulations (Pate and Merryweather, 2012); however, the General Duty clause of the Occupational Health and Safety Act (Public Law 91-596) indicates that a farm employer is subject to OSHA enforcement of citations and penalties for confined-space hazards. Targeting interventions to change human behavior and decision-making will play a pivotal role in reducing the number and severity of incidents involving confined spaces associated with agricultural production (Kingman et al., 2004; Mosher et al., 2012; Murphy, 2003).

Unsafe behaviors are often attributed to a complex interaction of factors, such as an individual's attitude, perceptions, and/or lack of knowledge (Daugherty, 1999; Mosher et al., 2012). Constructivist-based learning theories suggest that numerous influences, such as family traditions and traumatic events, can shape the adoption or learning of behaviors as well as modify well-established behavioral patterns (Bandura, 1986, 1994). Murphy (2003) documented this through the explanation of the "farm safety–risk paradox," where cultural influences and everyday experiences shape the attitudes and behaviors of farmers. Sanderson et al. (2010) concluded that, as children progress to young adults, they develop clear ideas about how to farm safely through a process called "farm apprentice," which involves observational learning and modeling of mentors. Sanderson et al. (2010) reported that agricultural college students described themselves as being exposed to dangerous activities at an early age, and they believed they had the capacity to control injury risks. An individual's beliefs concerning safety lead to the development of behavioral intentions that serve as precursors to behavior such as placing oneself in a dangerous work environment (Rundmo and Hale, 2003). Bandura (1994) argued that, in addition to information on how to change their habits, individuals need motivation, resources, and social support to be successful. Bandura (1994) suggested that engaging in self-protective action requires self-regulated skills combined with a high sense of self-efficacy to exercise control over hazardous situations. Diffusion of Innovations (Rogers, 1995) and the Theory of Reasoned Action and Planned Behavior (Ajzen, 2005; Ajzen and Fishbein, 1980) have been used by public health professionals in predicting and facilitating the adoption of safe behaviors within communities. Haider and Kreps (2004) stated that public health professionals can influence behaviors through the development of programming that integrates socio-cultural motivators.

Kingman et al. (2004) found that management decisions, such as controlling the moisture content of stored grain, along with an individual's perception of risk and willingness to avoid flowing grain hazards had the most significant impact on reducing the potential for grain engulfments. Kingman et al. (2004) recommended the use of training in hazard recognition and assessment to prevent fatal and non-fatal injures associated with grain storage facilities. For this study, we theorized that variables including the adoption level of safety planning, injury concerns, frequency of exposure to confined spaces, and selected demographic characteristics influence the level of farm owner/operators' hazard perceptions of agricultural confined spaces (Jenkins et al., 2012; Kingman et al., 2004; Mosher et al., 2012; Payne et al., 2012; Roberts and Field, 2010; Wadud et al., 1998).

## Purpose and Objectives

The purpose of this study was to assess how the variables of interest affect hazard perceptions of farm and ranch owner/operators in Utah. The main objectives for this study were:

1. Determine the influences of the owner/operators' level of safety planning, injury concern, and frequency of exposure to confined spaces, as well as selected demographic characteristics, on their perceived risks of confined-space work.
2. Identify variations of these influences on confined-space hazard perceptions by region within the state of Utah.

## Methodology

### Participants

A proportionate stratified random sample was taken of Utah farmers registered with the Utah Agricultural Statistics Field Office who had either grain storage capacity of 5000 bushels or more, 200 or more head of dairy cattle, 500 or more head of swine, or poultry operations with 1000 birds or more. Cash grain production operations were selected due to the confined spaces associated with grain storage, which has been documented as a significant source of deaths in agriculture (Roberts and Field, 2010). Livestock operations were selected based on the number of animals on site that would require the use of bulk feed bins, a silage storage facility, and/or a manure handling system (Sinnard, 1952; Johnston and Hawton, 2008; Radunz, 2010). Manure handling systems have also been documented as major sources of fatalities related to confined spaces in agriculture (Beaver and Field, 2007). There were 482 operations that met the sample selection criteria. A total of 83 individuals were inaccessible due to death or incorrect contact information, reducing the sample frame to 399 individuals.

A paper form survey was mailed to individuals meeting the selection criteria. Farm owner/operators were offered an incentive to complete the questionnaire in the form of a $5 gift card to a farm supply store. A postcard reminder to complete the survey was mailed to individuals who had not responded to the survey approximately two weeks after the initial mailing. Follow-up telephone calls were made to individuals who had not responded approximately two weeks after the postcard reminder. Upon completion of the

**Table 1. Survey response type by Community Collaborative Rain, Hail, and Snow (CoCoRaHS) region.**

| | Response Type ($N$ = 303) | |
|---|---|---|
| Region | Mail | Telephone |
| Central | 18 | 11 |
| East | 22 | 16 |
| Northeast | 3 | 11 |
| Northwest | 75 | 67 |
| Southwest | 36 | 44 |

follow-up calls, 303 out of 327 surveys had been returned with complete responses. Only surveys with complete responses were used for analysis with general linear modeling (GLM). The respondents completed the survey in one of two ways. There were 154 individuals who responded via mail and 149 who responded via a follow-up call. Table 1 provides a summary of the number of participants by response type. In the northeast region, only three individuals responded via mail.

### Survey Instrument

Participants were asked to indicate their perceived level of risk that a potential fatal injury could occur while performing 16 agricultural confined-space work tasks. Risk ratings were coded "1" for not a risk, "2" low risk, "3" moderate risk, or "4" high risk for each work task. Respondents' risk ratings were summated for a possible score range between 16 and 64. For survey reliability, Cronbach's alpha coefficients were calculated for hazard concerns ($\alpha$ = 0.91, 16 items). Respondents were also asked to identify if they performed specific safe entry or injury prevention practices involving agricultural confined-space work on their farms by indicating yes, no, or not applicable ($\alpha$ = 0.87, 13 items). The survey instrument was reviewed by four agricultural safety experts for content validity in order to determine the degree to which the survey item constructs represented a proper sample of the theoretical content domain of agricultural confined-space research. Experts also reviewed the survey face validity to determine whether the survey item constructs were appropriate for the objectives of the study. The survey was determined to have face and content validity.

### Selection of Predictor Variables

One of the leading causes of grain entrapment is related to the condition of stored grain (Riedel and Field, 2011; Kingman et al., 2004). This is impacted by weather patterns associated with geographic locations during the harvesting season. Excessive moisture created by excessive or early snowfall or rainfall during harvest and storage creates conditions for grain to spoil, leading to bridging or clumping and creating a scenario in which individuals believe they must enter the bin to dislodge the grain mass (Field, 1997). In contrast to the climate of the U.S. Corn Belt, most of Utah is considered arid, with precipitation varying regionally depending on elevation and weather patterns. As a result, Utah's five Community Collaborative Rain, Hail, and Snow (CoCoRaHS) regions vary in their types of production, as well as farmers' age and education level. For the southwest region, more respondents were engaged in "other" production than in the other four regions.

Utah has a unique climate, resulting in varying precipitation across the state, with regions below 1200 m (4000 ft) elevation averaging less than 254 mm (10 in.) of precipitation per year (UCCW, 2014). This varying precipitation, combined with the topography and land available for production, greatly impacts the agricultural economy, dictating a commodity production consisting mainly of livestock and dairy. Utah's crop production is primarily located in mountain valleys, where cultivation occurs at elevations between 900 and 2100 m (3000 and 7000 ft) (USDA-NASS, 2014). Farmers and ranchers are very dependent on snowpack and reservoir levels to provide irrigation water throughout the growing season (USDA-NASS, 2014). Regional agricultural production types vary based on precipitation received, thereby influencing farm owner/operators' perceptions based on their familiarity with grain storage. Therefore, the modeling analysis was organized by geographic area using the CoCoRaHS regions for the state of Utah (fig. 1).

Production type influences producers' awareness and acceptance of confined-space hazards. Two-thirds of Utah's total agricultural cash receipts are generated from cattle, milk, and hay sales (USDA-NASS, 2014). Agricultural production types that are associated with confined spaces such as grain storage bins, silos, and manure pits may view confined-space hazards as part of their work culture. There is a possibility that they ac-

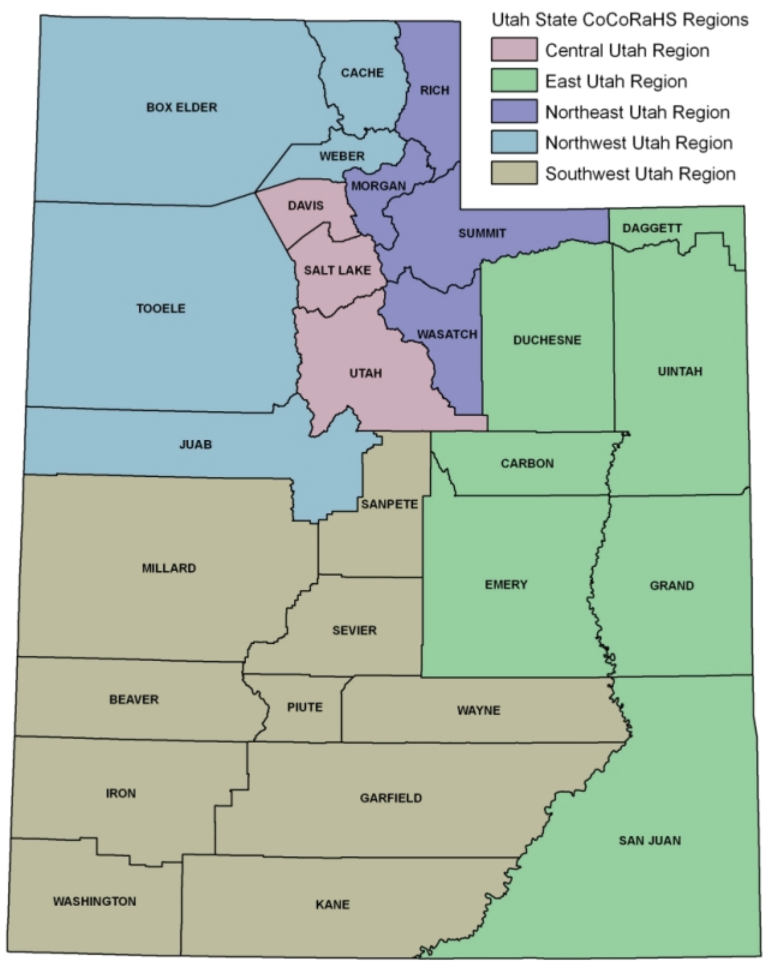


**Figure 1. Community Collaborative Rain, Hail, and Snow (CoCoRaHS) regions in Utah.**

cept confined-space hazards as "part of the job" (Murphy, 2003). Other production types differ in their working environment and limit workers' exposure to confined-space risks. Productions were classified into three types (animals, grains, and other) in the studied regions. The "other" category includes individuals who were not primarily engaged in grain (wheat, barley, corn, etc.), beef, or dairy production.

Age and education level have been shown to be linked to attitudes toward safe behaviors and risk acceptance (Westaby and Lee, 2003; Jonah, 1986; Murphy, 2003). Younger individuals may engage in higher-risk behaviors when working in confined spaces. Murphy (2003) indicated that a risk-reward benefit can influence these individual's decisions to continue engaging in hazardous activities. Individuals with levels of education beyond high school are more likely to have a greater sense of control over their health and are less likely to engage in risky behaviors (Ross and Wu, 1995). For GLM analysis, respondents were classified into three age groups: young (20 to 39 years), middle-aged (40 to 59 years), and senior (60+ years). An additional variable was included for respondents' education level as either "associate/college degree" or "no college degree."

Working in unsafe conditions without incident can create a false sense of security associated with the risk-reward benefit, with the individual concluding "I'm careful" or "nothing has happened to me." These attitudes are influenced by the amount of exposure to confined spaces and can lead to the belief that an individual is not susceptible to risks (Vaughn, 1993; Weinstein et al., 1991). A normative belief of farmers and ranchers is that working in confined spaces is acceptable, along with the risks associated with such activity (Murphy, 2003; Wicks, 2001). For our analysis, we selected the work exposure variables to be the number of confined spaces that respondents listed for their operations and the number of confined-space entries that they performed in the preceding 12 months. We included respondents' concerns that an injury and/or death would occur from working in a confined space on their operation. As a gauge of normative beliefs, our analysis included respondents' knowledge of anyone who had been injured or killed due to working in a confined space and their own experiences of having a "close call" while working in a confined space. An additional variable that we chose to serve as an indicator of respondents' levels of concern regarding confined-space safety was their mode of response. The participants responded in one of two ways: they either returned their completed survey via U.S. mail, or they completed the survey via telephone follow-up call. Those who responded by mail were assumed to be more serious about the survey and about confined-space hazards. Following the research of Kingman et al. (2004), responses from participants who indicated using confined-space hazard identification and safety response plans were assigned a weighting of 0, while those who indicated not using confined-space identification and safety response plans were assigned a weighting of 1.

The data were summarized using frequencies, percentages, means, and correlations. An exploratory factor analysis was conducted with the goal of identifying the underlying factor structure using the FACTOR procedures in SAS/STAT 12.1 (SAS 9.3, SAS Institute, Inc., Cary, N.C.). Three-factor models were chosen based on the analysis. Factor scores for the respondents were calculated and followed by GLM (SAS/STAT 12.1, SAS 9.3) analysis to assess the three factors' impacts on respondents' hazard risk rating scores. Analyses were conducted for each region. Impact significance was defined at $\alpha$ = 0.05.

**Table 2. Distribution of respondents between CoCoRaHS regions.**

| Region | Respondents | Complete Surveys |
|---|---|---|
| Central | 31 | 29 |
| East | 42 | 38 |
| Northeast | 15 | 14 |
| Northwest | 154 | 142 |
| Southwest | 85 | 80 |
| Total | 327 | 303 |

**Table 3. Distribution of production types between CoCoRaHS regions (*N* = 303).**

| | Production Type | | |
|---|---|---|---|
| Region | Animals | Grains | Other |
| Central | 17 | 8 | 4 |
| East | 17 | 12 | 9 |
| Northeast | 12 | 1 | 1 |
| Northwest | 71 | 50 | 21 |
| Southwest | 52 | 7 | 21 |

# Results

Table 2 summarizes the distribution of respondents by CoCoRaHS region. As shown in table 3, most respondents were engaged in livestock production. The distribution of production types differed by region. Seven respondents were in grain production in the southwest region, but 52 were in animal production. Animal production operations had the highest average number of confined spaces ($\mu$ = 4, SD = 2.7). Regionally, the northwest had the highest average number of confined spaces ($\mu$ = 4, SD = 2.5).

## Respondent Demographics

The northeast region had the highest percentage of respondents with education beyond high school or GED; 64.3% indicated having an associate/college degree. For the northwest region, 32% of respondents had an associate/college degree. The majority of respondents were middle-aged or seniors (table 4). Young farmers comprised less than 10% of the respondents, except in the northeast region, where they were 14.3% of respondents. The lowest percentage of respondents in the young age group was found in the central region (3.4%). Sixteen of the 303 completed surveys were from female respondents.

## Correlations of Variables and Factorial Analysis

Eight measured variables were of interest as predictors for the farmers' hazard scores. Table 5 presents inter-correlations among these eight variables. Significant correlations between measured variables indicated that the survey questions contained redundant information and can be summarized into fewer common underlying factors. Since the inter-correlations were different by region, factor analysis was performed for each region using

**Table 4. Distribution of respondents' age groups by CoCoRaHS region (*N* = 303).**

| | Age Category | | |
|---|---|---|---|
| Region | Young: 20-39 Years (%) | Middle-aged: 40-59 Years (%) | Senior: 60+ Years (%) |
| Central (*n* =29) | 3.4 | 55.2 | 41.4 |
| East (*n* = 38) | 7.9 | 42.1 | 50.0 |
| Northeast (*n* = 14) | 14.3 | 35.7 | 50.0 |
| Northwest (*n* = 142) | 7 | 52.1 | 40.8 |
| Southwest (*n* = 80) | 5.0 | 55.0 | 40.0 |

PROC FACTOR in SAS 9.3. Factors were extracted using principle factor analysis (PFA), with patterns revealed by orthogonal varimax rotation. A common practice is to choose loadings greater than 0.30. Variables load to more than one factor but load at different values. In this case, each variable was selected to the factor with the highest loading. Injury concern and death concern loaded highest on factor 1 (susceptibility) for all five regions (table 6). Susceptibility was defined as a concern that an incident can occur at work.

The loading of variables for factor 2 (personal proximity) varied by region. Factor 2 was defined as personal proximity to a confined-space incident involving injury or death.

**Table 5. Correlation coefficients among variables.[a]**

| Region | Variable | Gender | Experience | Knowledge | Injury Concern | Death Concern | Entry History | No. of Confined Spaces | Safety Plan |
|---|---|---|---|---|---|---|---|---|---|
| Central | Gender | 1.000 | | | | | | | |
| | Experience | 0.223 | 1.000 | | | | | | |
| | Knowledge | -0.080 | -0.147 | 1.000 | | | | | |
| | Injury concern | -0.002 | 0.080 | 0.239 | 1.000 | | | | |
| | Death concern | 0.000 | 0.000 | 0.214 | 0.845* | 1.000 | | | |
| | Entry history | -0.259 | -0.113 | 0.045 | 0.348 | 0.305 | 1.000 | | |
| | No. of confined spaces | -0.121 | 0.198 | 0.091 | 0.509* | 0.467* | 0.189 | 1.000 | |
| | Safety plan | 0.318 | 0.109 | -0.065 | 0.266 | 0.362 | 0.116 | 0.223 | 1.000 |
| East | Gender | 1.000 | | | | | | | |
| | Experience | 0.043 | 1.000 | | | | | | |
| | Knowledge | 0.012 | 0.355* | 1.000 | | | | | |
| | Injury concern | -0.337* | 0.292 | 0.159 | 1.000 | | | | |
| | Death concern | -0.312 | 0.327 | 0.158 | 0.925* | 1.000 | | | |
| | Entry history | 0.109 | 0.218 | 0.128 | 0.224 | 0.158 | 1.000 | | |
| | No. of confined spaces | 0.045 | 0.182 | 0.198 | 0.163 | 0.146 | 0.323 | 1.000 | |
| | Safety plan | 0.034 | 0.278 | 0.059 | 0.066 | 0.104 | 0.105 | -0.013 | 1.000 |
| Northeast | Gender | 1.000 | | | | | | | |
| | Experience | -0.284 | 1.000 | | | | | | |
| | Knowledge | 0.213 | 0.417 | 1.000 | | | | | |
| | Injury concern | -0.075 | 0.471 | 0.059 | 1.000 | | | | |
| | Death concern | -0.220 | 0.455 | 0.030 | 0.966* | 1.000 | | | |
| | Entry history | -0.034 | 0.583* | 0.583* | 0.122 | 0.130 | 1.000 | | |
| | No. of confined spaces | 0.197 | -0.054 | 0.021 | 0.099 | 0.092 | -0.159 | 1.000 | |
| | Safety plan | -0.251 | 0.471 | 0.059 | 0.854* | 0.815* | 0.319 | -0.220 | 1.000 |
| Northwest | Gender | 1.000 | | | | | | | |
| | Experience | 0.032 | 1.000 | | | | | | |
| | Knowledge | -0.170* | 0.107 | 1.000 | | | | | |
| | Injury concern | -0.307* | 0.306* | 0.291* | 1.000 | | | | |
| | Death concern | -0.314* | 0.368* | 0.330* | 0.853* | 1.000 | | | |
| | Entry history | -0.093 | 0.138 | 0.230* | 0.180* | 0.106 | 1.000 | | |
| | No. of confined spaces | -0.187 | 0.139 | 0.161 | 0.194* | 0.143 | 0.232* | 1.000 | |
| | Safety plan | -0.001 | -0.028 | 0.003 | -0.003 | 0.007 | 0.144 | 0.166 | 1.000 |
| Southwest | Gender | 1.000 | | | | | | | |
| | Experience | -0.031 | 1.000 | | | | | | |
| | Knowledge | -0.274* | 0.214 | 1.000 | | | | | |
| | Injury concern | -0.322* | 0.259* | 0.366* | 1.000 | | | | |
| | Death concern | -0.322* | 0.181 | 0.374* | 0.892* | 1.000 | | | |
| | Entry history | -0.175 | 0.257* | 0.168 | 0.542* | 0.436* | 1.000 | | |
| | No. of confined spaces | -0.128 | 0.119 | 0.185 | 0.416* | 0.328* | 0.406* | 1.000 | |
| | Safety plan | -0.089 | 0.125 | -0.047 | -0.014 | -0.085 | -0.021 | 0.202 | 1.000 |

[a] Asterisk (*) indicates $p < 0.05$.

**Table 6. Factor pattern with loadings for variables of interest (coefficients ≥0.31 shown in bold).**

| Region | Variable | Factor 1: Susceptibility | Factor 2: Personal Proximity | Factor 3: Exposure |
|---|---|---|---|---|
| Central | Injury concern | **0.9089** | 0.1080 | -0.0431 |
| | Death concern | **0.9008** | 0.1604 | -0.1340 |
| | No. of confined spaces | **0.5799** | -0.0647 | 0.2292 |
| | Entry history | **0.3748** | -0.1702 | -0.1338 |
| | Response type | -0.1361 | **0.9851** | 0.1413 |
| | Safety plan | **0.3193** | **0.3381** | 0.0953 |
| | Experience | 0.0803 | 0.1337 | **0.7066** |
| | Knowledge | 0.2056 | -0.0389 | -0.2162 |
| East | Injury concern | **0.9519** | 0.1664 | 0.2609 |
| | Death concern | **0.8813** | 0.2283 | 0.1817 |
| | Response type | **-0.4003** | 0.0595 | 0.1398 |
| | Experience | 0.0863 | **0.9830** | 0.1703 |
| | Knowledge | 0.0562 | 0.3031 | 0.2284 |
| | Safety plan | 0.0212 | 0.2748 | 0.0248 |
| | No. of confined spaces | 0.0215 | 0.0791 | **0.5704** |
| | Entry history | 0.0372 | 0.1315 | **0.5501** |
| Northeast | Injury concern | **1.0058** | 0.0765 | 0.1017 |
| | Death concern | **0.9703** | 0.0497 | -0.0239 |
| | Safety plan | **0.8243** | 0.1843 | -0.3201 |
| | Entry history | 0.0929 | **0.8202** | -0.2011 |
| | Knowledge | -0.0136 | **0.7944** | 0.2470 |
| | Experience | **0.4248** | **0.5875** | -0.2541 |
| | Response type | -0.1731 | 0.0654 | **0.5552** |
| | No. of confined spaces | 0.0549 | -0.0797 | **0.4265** |
| Northwest | Death concern | **0.9808** | -0.2083 | -0.0279 |
| | Injury concern | **0.8233** | -0.2126 | 0.0985 |
| | Experience | **0.3932** | 0.1060 | 0.1298 |
| | Knowledge | 0.3027 | -0.1222 | 0.2534 |
| | Response type | -0.1312 | **0.8944** | -0.1037 |
| | Entry history | 0.1406 | -0.0159 | **0.5534** |
| | No. of confined spaces | 0.1436 | -0.1269 | **0.4396** |
| | Safety plan | -0.0232 | 0.0102 | 0.2642 |
| Southwest | Death concern | **0.8738** | 0.2582 | -0.0870 |
| | Injury concern | **0.8737** | **0.3852** | -0.0165 |
| | Knowledge | **0.4288** | 0.1000 | -0.0143 |
| | Response type | **-0.3628** | -0.0858 | -0.0786 |
| | Entry history | 0.1982 | **0.9776** | -0.0748 |
| | No. of confined spaces | 0.2983 | **0.3648** | 0.1802 |
| | Experience | 0.1867 | 0.2228 | 0.1040 |
| | Safety plan | -0.0240 | 0.0641 | **0.9994** |

Depending on region, the defining variables for factor 2 included experience of having a “close call” while working in a confined space, knowledge of a confined-space related death or injury, number of confined-space entries in the last 12 months, number of confined spaces identified on the production site by the owner/operator, having a safety plan, and survey response type. For three of the five regions, the number of on-farm confined spaces loaded on factor 3 with coefficients ≥0.31. Factor 3 was defined as exposure. Exposure was considered to be the amount of an individuals’ interaction with working in and around confined spaces. Additional variable loadings with coefficients ≥0.31 varied by region. Caution is recommended in interpreting the factor pattern for the northeast region due to the small number of respondents from that region. The variances explained by the three factors ranged from 61% to greater than 95% depending on the region.

### *Central Region Factor Descriptions*

The defining variables for factor 1 (susceptibility) were injury concern and death concern when working alone in a confined space, number of confined spaces, and number of confined-space entries. The number of confined-space entries and number of on-farm confined spaces loaded on factor 1 with coefficients greater than 0.31. For factor 2 (personal proximity), response type loaded with the most weight, followed by having a safety plan, both with coefficients ≥0.31. The only variable loading with a coefficient ≥0.31 on factor 3 (exposure) was experience of a close call.

### *East Region Factor Descriptions*

In addition to the variables injury concern and death concern, response type loaded on factor 1 (susceptibility) with a coefficient ≥0.31. For factor 2 (personal proximity), experience of a close call was the only variable loading with a coefficient ≥0.31. The variables with the highest loadings on factor 3 (exposure) included the number of confined-space entries in the last 12 months and the number of on-farm confined spaces identified by the owner/operator.

### *Northeast Region Factor Descriptions*

In the northeast region, in addition to injury concern, death concern, and having a safety plan, experience loaded on factor 1 (susceptibility) with a coefficient ≥0.31. Variables with the highest loadings on factor 2 (personal proximity) included number of confined-space entries in the last 12 months, followed by knowledge of a confined-space related injury or death and experience of a close call. Variables with the highest loadings on factor 3 (exposure) included response type and number of on-farm confined spaces identified by the owner/operator.

### *Northwest Region Factor Descriptions*

For factor 1 (susceptibility), the highest variable loadings (coefficients ≥0.31) were for injury concern and death concern when working alone in a confined space and experience of a close call. The variable with the highest loading (coefficient ≥0.31) on factor 2 (personal proximity) was response type. The variables with the highest loadings on factor 3 (exposure) included number of confined-space entries in the last 12 months, followed by number of on-farm confined spaces identified by the owner/operator.

### *Southwest Region Factor Descriptions*

For the southwest region, the highest loading variables for factor 1 (susceptibility) were death concern and injury concern. Knowledge of anyone injured or killed due to working in a confined space and response type also contributed to factor 1 (susceptibility) with coefficients ≥0.31. Variable loadings (coefficients ≥0.31) on factor 2 (personal proximity) were number of confined-space entries in the last 12 months and number of on-farm confined spaces identified by the owner/operator. The variable with the highest loading (coefficient ≥0.31) on factor 3 (exposure) was having a safety plan.

## Modeling Predictors of Hazard Perceptions by CoCoRaHS Region

Hazard perception scores were analyzed using generalized linear modeling (GLM) with Proc GLM in SAS 9.3. The dependent variable was the hazard score of each respondent. The seven predictors were production type, gender, age, education level, and factors 1, 2, and 3 (table 6). Two-way interactions between production type and the factors were also included in the model. Selection of the best model was based on adjusted

**Table 7. Central region's generalized linear model for predicted hazard score.**

| Source | DF | SS | Mean | F-Value | p-Value |
|---|---|---|---|---|---|
| Production type | 2 | 161.81 | 80.91 | 1.04 | 0.3732 |
| Gender | 1 | 214.45 | 214.45 | 2.75 | 0.1131 |
| Age group | 2 | 507.39 | 253.70 | 3.25 | 0.06 |
| Factor 1 | 1 | 812.57 | 812.57 | 10.4 | 0.0042 |
| Factor 2 | 1 | 13.36 | 13.36 | 0.17 | 0.6835 |
| Factor 3 | 1 | 0.025 | 0.025 | 0.00 | 0.986 |

**Table 8. Differences in LS-mean hazard scores between central region respondent types.**

| Respondent Demographic Classifications | | LS-Means[a] |
|---|---|---|
| Production type | Other | 34.1 |
| | Animals | 26.6 |
| | Grains | 26.0 |
| Age group | Senior (60+) | 38.1 |
| | Middle-aged (40-59) | 32.2 |
| | Young (20-39) | 16.5* |

[a] Asterisk (*) indicates p < 0.05. Comparisons on LS-mean hazard scores were not made between respondent demographic classifications.

$R^2$, residual diagnostics, and model interpretability.

### *Central Region GLM Analysis*

The most significant effect on hazard score was from factor 1 (susceptibility) (p = 0.0042). The model's estimates showed that a single-unit increase in factor 1 increased the hazard score by 6.5 points (table 7). Both factor 2 (personal proximity) and factor 3 (exposure) did not affect the hazard scores. The LS-mean hazard scores for production type and age group are shown in table 8. Production type did not have a statistically significant effect on respondents' hazard scores. Respondents' ages had an effect, but it was not statistically significant (p = 0.06). Respondents belonging to the young age group had an LS-mean hazard score of 16.5, which was significantly lower (p = 0.0442) than that of respondents belonging to the senior age group ($\mu$ = 38.1). There was no difference between the LS-mean hazard scores of respondents belonging to the middle-aged and senior age groups. The $R^2$ value of the selected model was 0.59.

### *East Region GLM Analysis*

As shown in table 9, factor 1 (susceptibility) was the most significant factor (p = 0.0074). A single-unit increase in factor 1 increased the hazard score by 5.7 points. The interaction between factor 3 (exposure) and production type was also significant. Estimates of factor 3 showed that while increasing factor 3 decreased the hazard score for animal and grain farmers, it increased the hazard score for other production types (p < 0.05). Respondents' demographics also affected their hazard scores. Females' mean hazard score was significantly lower than that of males (p = 0.0495). LS-means for produc-

**Table 9. East region's generalized linear model for predicted hazard score.**

| Source | DF | SS | MSE | F-Value | p-Value |
|---|---|---|---|---|---|
| Production type | 2 | 88.65 | 44.32 | 0.4 | 0.6758 |
| Gender | 1 | 471.30 | 471.29 | 4.23 | 0.0495 |
| Education Group | 1 | 8.04 | 8.04 | 0.07 | 0.7903 |
| Prod. type × Educ. Group | 2 | 685.13 | 342.56 | 3.07 | 0.0627 |
| Factor 1 | 1 | 936.42 | 936.42 | 8.4 | 0.0074 |
| Factor 3 | 1 | 35.11 | 35.11 | 0.31 | 0.5793 |
| Factor 3 × Prod. type | 2 | 1019.54 | 509.77 | 4.57 | 0.0195 |

**Table 10. Differences in mean hazard scores between east region respondent types.**

| Respondent Demographic Classifications | | LS-Means[a] |
|---|---|---|
| Production type | Other | 34.6 |
| | Animals | 36.1 |
| | Grains | 38.8 |
| Gender | Male | 44.0 |
| | Female | 28.9* |
| Education group | Associate/college degree | 37.0 |
| | No college degree | 36.0 |

[a] Asterisk (*) indicates $p < 0.05$. Comparisons on LS-mean hazard scores were not made between respondent demographic classifications.

**Table 11. Northeast region's generalized linear model for predicted hazard score.**

| Source | DF | SS | MSE | F-Value | p-Value |
|---|---|---|---|---|---|
| Production type | 2 | 38.56 | 19.28 | 1.79 | 0.2589 |
| Gender | 1 | 14.03 | 14.03 | 1.3 | 0.3051 |
| Education group | 1 | 17.63 | 17.63 | 1.64 | 0.2566 |
| Factor 1 | 1 | 0.90 | 0.90 | 0.08 | 0.784 |
| Factor 2 | 1 | 147.15 | 147.15 | 13.68 | 0.014 |
| Factor 3 | 1 | 154.15 | 154.15 | 14.33 | 0.0128 |
| Factor 3 × Educ. group | 1 | 115.17 | 115.17 | 10.71 | 0.0221 |

tion type, gender, and education group are listed in table 10. The $R^2$ value of the selected model was 0.52.

### *Northeast Region GLM Analysis*

Factor 1 did not significantly affect hazard score (table 11), but factor 2 (personal proximity) significantly affected hazard score ($p = 0.014$). A single-unit increase in factor 2 increased the hazard score by 4.4 points. The effect of factor 3 was dependent on education level of the respondents. Factor 3 did not affect the hazard scores of those with higher education (associate/college degree), but hazard scores of respondents with no college degree were significantly affected by factor 3 ($p = 0.021$). An increase in factor 3 increased their hazard scores by 11.9 points. There was only one observation for grains and other production types. Therefore, interactions of production type and the three factors were not included in the model. The $R^2$ value of the selected model was 0.90.

### *Northwest Region GLM Analysis*

Factor 1 had a highly significant effect on the hazard scores of the respondents (table 12). A single-unit increase in factor 1 increased the hazard score by 4.4 points. Factors 2 and 3 did not statistically affect the respondents' hazard scores. The LS-mean hazard scores for the different production types and the three age groups are listed in table 13. Although the LS-mean hazard score for "other" production is higher than for animal and grain production, the differences are not significant. In addition, there was no significant difference in hazard scores between animal and grain production. Similarly,

**Table 12. Northwest region's generalized linear model for predicted hazard score.**

| Source | DF | SS | MSE | F-Value | p-Value |
|---|---|---|---|---|---|
| Production type | 2 | 338.67 | 169.33 | 1.58 | 0.2108 |
| Age group | 2 | 243.17 | 121.58 | 1.13 | 0.3258 |
| Factor 1 | 1 | 2594.86 | 2594.86 | 24.14 | <.0001 |
| Factor 2 | 1 | 154.79 | 154.79 | 1.44 | 0.2323 |
| Factor 2 × Prod. type | 2 | 232.71 | 116.36 | 1.08 | 0.3418 |
| Factor 3 | 1 | 0.50 | 0.50 | 0.00 | 0.9457 |

**Table 13. Differences in LS-mean hazard scores between northwest region respondent types.**

| Respondent Demographic Classifications | | LS-Means[a] |
|---|---|---|
| Production type | Other | 43.9 |
| | Animals | 39.8 |
| | Grains | 42.2 |
| Age group | Senior (60+) | 44.2 |
| | Middle-aged (40-59) | 43.0 |
| | Young (20-39) | 38.7 |

[a] Comparisons on LS-mean hazard scores were not made between respondent demographic classifications.

seniors and middle-aged farmers had higher hazard scores than young farmers (table 13), but neither of the pairwise differences was significant at the 0.05 level. The $R^2$ value of the selected model was 0.23.

### *Southwest Region GLM Analysis*

Although the variable for experience of a close call was not selected in any of the three factors, it was included in the model as an additional term to test its effect on hazard score. Interaction between experience and the three factors was also tested. The selected model is shown in table 14. The $R^2$ value of the model was 0.40.

Factor 1 had a statistically significant effect on hazard score ($p = 0.0286$). A single-unit increase in factor 1 increased the hazard score by 4.4 points. The effect of factor 2 depended on age group ($p = 0.0745$). Increasing factor 2 increased the hazard scores for young and middle-aged respondents but decreased the senior respondents' hazard score. Respondents' hazard scores did not differ significantly between production types.

Both respondents' ages and education levels significantly affected their hazard scores ($p = 0.0166$ and 0.0003, respectively). Young farmers' mean hazard scores were lower than those of middle-aged and senior farmers (table 15). Respondents with higher education had significantly higher hazard scores than respondents without college degrees.

**Table 14. Southwest region's generalized linear model for predicted hazard score.**

| Source | DF | SS | MSE | F-Value | Pr > F |
|---|---|---|---|---|---|
| Production type | 2 | 200.95 | 100.48 | 1.24 | 0.2950 |
| Age group | 2 | 704.18 | 352.09 | 4.36 | 0.0166 |
| Education group | 1 | 1184.38 | 1184.38 | 14.65 | 0.0003 |
| Experience | 1 | 108.07 | 108.07 | 1.34 | 0.2517 |
| Factor 1 | 1 | 404.77 | 404.77 | 5.01 | 0.0286 |
| Factor 1 × Experience | 1 | 143.25 | 143.25 | 1.77 | 0.1876 |
| Factor 2 | 1 | 0.75 | 0.75 | 0.01 | 0.9237 |
| Factor 2 × Age | 2 | 436.44 | 218.22 | 2.70 | 0.0745 |
| Factor 3 | 1 | 250.54 | 250.54 | 3.10 | 0.0829 |

**Table 15. Differences in LS-mean hazard scores between southwest region respondent types.**

| Respondent Demographic Classifications | | LS-Means[a] |
|---|---|---|
| Production type | Other | 41.5 |
| | Animals | 39.4 |
| | Grains | 34.8 |
| Age group | Senior (60+) | 40.2 |
| | Middle-aged (40-59) | 44.4 |
| | Young (20-39) | 31.1* |
| Education group | Associate/college degree | 42.6 |
| | No college degree | 34.5* |

[a] Asterisk (*) indicates $p < 0.05$. Comparisons on LS-mean hazard scores were not made between respondent demographic classifications.

## Conclusions, Implications, and Recommendations

In all regions, animal production was most prominent, followed by grain production. Similar to USDA 2007 Census of Agriculture statistics (USDA-NASS, 2009), most respondents (76.6%) in this study were 50 to 70 years old. The east region had the highest frequency of respondents ($n$ = 22) within the young age group (20 to 39 years). The number of respondents with higher education was highest for the southwest ($n$ = 44) and northwest ($n$ = 45) regions. Few female farm and ranch owner/operators participated in this study.

The influences on the respondents' confined-space hazard perceptions varied by region. Three factors were developed to summarize the variation in influences. Overall, individuals who responded through telephone follow-up indicated a lower concern that working alone in a confined space can result in injury or death. Respondents' demographic variables also influenced their hazard scores differently between regions. In the southwest region, young farmers perceived the risks to be lower, and farmers with higher education had significantly higher perceptions of risks. Interactions between respondents' demographic variables and the three factors were different between regions, and factor loadings were different between regions. This indicates that a "one size fits all" training program is not recommended for increasing agricultural producers' perceptions of confined-space hazards.

Factor 1 (susceptibility) was mostly contributed to by the variables for injury concern and death concern when working alone in confined spaces. Except for respondents from the northeast region, these variables were the most significant contributors to the respondents' hazard scores. Factor 2 (personal proximity) was mostly contributed to by the variables for experiencing a close call in a confined space and knowledge of a confined-space related death or injury. The variables for entering confined spaces and for the presence of confined spaces on the site contributed to factor 2 for the northwest and east regions. Factor 2 did not significantly predict hazard perceptions for the central, east, and northwest regions. For the northeast region, factor 2 increased respondents' hazard risk perception. Factor 2 interacted with respondent age for the southwest region. Younger southwest respondents' hazard scores were more influenced by factor 2. Factor 3 (exposure) did not significantly predict hazard scores for the central, east, northwest, and southwest regions. However, interactions between production type and factor 3 significantly influenced respondents' hazard scores for the east region. Factor 3 lowered hazard perceptions for animal and grain production operations but increased hazard scores for other production types.

A higher perception of injury susceptibility by the respondents in this study correlated with a higher risk perception of confined-space work. It is recommended that confined-space safety training programs address this correlation between individuals' perceived injury susceptibility and their perception of the risks of working in confined spaces. Such programs have the potential to reduce confined-space incidents in agriculture among farmers and ranchers who have perceptions that fatalities and injuries are unlikely to be associated with confined-space work tasks. Interventions should include training segments that introduce farmers and ranchers to the statistical probability of fatal and non-fatal confined-space incidents, as well as the impacts on the surrounding community.

Future research should focus on determining the effectiveness of training best practices for increasing farmers' and ranchers' perceived susceptibility to confined-space incidents. Depending on region, an interpretation of the influences of factor 2 would be that the closer an individual is to a confined-space incident, the more likely that person is to perceive confined-space work as hazardous. For the east region, an interpretation of the influences of factor 3 would be that animal and grain production operations that require frequent work in and around confined spaces can create a false sense of security associated with risk-reward behaviors.

Future studies should be conducted with producers who have more interactions with confined spaces, such as the Midwestern states of the U.S., which have been reported to have the highest proportion of confined-space incidents (Riedel and Field, 2011). These individuals will likely have different levels of perceived susceptibility, personal proximity, and exposure to confined spaces. Outreach and educational efforts should be implemented to increase safety behaviors regarding confined-space work in Utah. These need to be strategically developed and targeted for each region based on predictive factors. It is recommended that regional stakeholders implement strategic plans to target agricultural producers' personal social networks to address human factors, such as worker's attitudes toward susceptibility and their confined-space hazard knowledge.

### Limitations

We acknowledge a potential limitation of this study, i.e., that surveys completed by telephone versus by mail can yield differences in individual responses. Fowler et al. (2002) concluded that conducting telephone follow-ups with mail non-respondents increases response rates and can produce fewer biased samples than mail-only protocols. It is unknown if the respondents in this study provided answers that they deemed socially acceptable or if their motivation to complete the survey was driven by the gift card offer. However, a few individuals completed the survey and did not wish to receive the gift card.

### Safety Emphasis

The data gathered through this study can be used to guide training programs to reduce the frequency of agricultural confined-space incidents.

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