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Perceptions of Agricultural College Students on the Relationship between Quality and Safety in Agricultural Work Environments

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Abstract

Agriculture is a high-hazard industry that employs a large number of young workers below the age of 25. Recent studies have documented a strong positive correlation between quality management in agriculture and occupational safety as perceived by agricultural workers. Younger workers have been found to be at higher risk for occupational injuries and fatalities in agriculture. Furthermore, college students in agriculture have minimal exposure to safety and quality management principles in their coursework and thus may not be aware that the two concepts are associated. Little research has studied how young workers perceive the relationship between safety and quality and how these perceptions vary based on demographic characteristics. This study builds on prior research that measured the interactions between employee perceptions of safety and quality in an agricultural work environment. Data were collected using a survey instrument adapted from a previously validated instrument. Analysis of 1017 responses showed that students perceived a high impact of quality practices on the reduction of safety hazards and safety incidents. Students' perceptions of quality and safety in agricultural work environments varied by gender, with female students perceiving the relationship between the two at a higher level than males. No significant difference in perceptions was observed based on students' academic classification, age group, field of study, or childhood environment. This study demonstrates that despite limited academic training in safety and quality, pre-professionals perceive the implementation of quality management as a very important factor in mitigating safety hazards and safety incidents. In addition, this study suggests that current academic training in these disciplines must be modified, since no differences in students' perceptions were observed based on academic classification or field of study.

Keywords

Hazard; Pre-professional; Quality management systems; Quality perception; Safety perception

Agriculture is generally considered a dangerous industry, yet it employs a large number of young workers below the age of 25. A study of international research literature concluded that young workers have the highest risk of occupational injury (Salminen, 2004). In the U.S., one young worker is killed every three days and 45 are injured each day in agriculture-related incidents (Wright et al., 2013).

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Pre-professional university students in the field of agriculture are young workers who will directly or indirectly impact the safety of agricultural workplaces in the future. Furthermore, technological advances, changes in health and safety regulations, rising health care and worker compensation costs, increased pressure from environmental groups, and increasing scrutiny of corporate responsibilities and organizational ethics have significantly changed occupational safety over the last two decades (Goetsch, 2008). In modern work environments, safety management is often viewed as a strategic tool that can improve a firm's competitiveness by indirectly impacting market share, profitability, and the firm's overall economic and financial performance (Fernandez-Muniz et al., 2009). Safety management has progressed from a traditional approach focused solely on hardware and design to a modern approach based more on cognitive human factors, such as employee perceptions (Mosher, 2013; Goetsch, 2008). This mindset shift in advancing safety management from a traditional approach to a holistic approach with strong emphasis on cognitive factors has been less prominent in the agricultural industry (Murphy, 2003). Although pre-professional students may have some agricultural safety experiences, not all of these experiences emphasize safety. Work practices in adulthood are highly dependent on the "farming apprenticeship" experienced by children raised in an agricultural environment (Sanderson et al., 2010). Even when hazards are recognized, perceptions may not reflect the level of hazard. However, thus far, little research has explored the perceptions and attitudes that agricultural students have toward occupational hazards in the agricultural work environment.

Globalization and legislation have also warranted radical changes in quality management, which historically has not been applied frequently in many areas of the agricultural industry (Hurburgh and Lawrence, 2003). A key game changer in the last decade was the U.S. Public Health Security and Bioterrorism Preparedness and Response Act of 2002, known as the Bioterrorism Act (FDA, 2002). The Bioterrorism Act requires that any facility engaged in manufacturing, processing, packing, or holding food for consumption must self-register with the U.S. Food and Drug Administration (FDA) and maintain records and information for food traceability purposes. A second law passed in 2011 was the Food Safety and Modernization Act, which requires even more structure in terms of preventing food safety and quality hazards. Both laws have potential impacts on worker safety in agriculture.

As one result of the legislation, greater attention has been given to the regulation of the quality processes of agricultural products and supplies. In the new economies of agriculture, purchase decisions are no longer based solely on price but also non-price attributes, such as product quality. Therefore, the agricultural industry has started to embrace quality management systems to not only improve operating efficiency and meet newer customer demands but to also help comply with tighter legal regulations (Laux and Hurburgh, 2010). Despite the growing importance of quality in agriculture, pre-professional students in the field of agriculture generally have very little preparation in formal quality management processes.

The relationship between safety and quality has always interested researchers. Starting from Dumas (1987) to Das et al. (2008), the consistent message suggests a strong theoretical link between safety and quality. In agriculture, Roberts and Field (2010) and Freeman et

al. (1998) observed that poor-quality grain has a higher likelihood to result in increased safety hazards, thus implying a practical connection between safety and quality. Mosher et al. (2012) empirically confirmed that agricultural employees also perceive these long-standing theoretical and practical connections between quality and safety in an agribusiness work environment. However, most of the previous research on perceptions within the agricultural work environment examined current employees. Very little is known about how pre-professional students perceive the link between safety and quality.

This research project builds on the work of Mosher et al. (2012), extending the study of quality and safety perceptions and their relationship to the academic environment. The first objective of this study was to measure the perceptions of pre-professional university students regarding the mitigating impact of quality management systems (QMS) on safety hazards and safety incidents and to validate if these perceptions are consistent with the theoretical and practical connections proposed by the previous research literature. The second objective was to explore how these perceptions varied based on students' demographic characteristics, such as gender, age group, academic classification, work experience, and childhood environment.

A thorough understanding of how future agricultural workers perceive the interaction between agricultural safety and quality provides better insight for the development of systems and protocols for managing safety. Furthermore, a systematic understanding of how future agricultural workers view hazards would enhance the management of hazards and risks, providing an opportunity to address worker safety issues with engineering-focused behavioral interventions rather than depending solely on educational and enforcement interventions.

Background

Merriam-Webster (www.merriam-webster.com) defines "pre-professional" as relating to the period preceding the practice of a profession. Based on this definition, university students in the field of agriculture are pre-professionals who upon graduation will directly or indirectly impact the safety of agricultural workplaces. Hence, the setting of this research was the College of Agriculture and Life Sciences at a large Midwestern public university. In this case, "college" refers to an administrative unit within a large, comprehensive research university that focuses on the delivery of undergraduate and graduate degree programs in the field of agriculture.

The latest figures released by the U.S. Census Bureau (2012) show that 79% of college students fall within the 18 to 24 year age group. These young workers below the age of 25 have the greatest risk for occupational injury and fatality (Janicak, 2000; Salminen, 2004; Miller et al., 2007). Even though young workers are exposed to similar occupational risks as adult workers, published research suggests that they are more likely to be injured than adult workers (Salminen, 2004). Lack of awareness of work-related hazards is one of the reasons given for such high injury rates among young workers (Miller et al., 2007). However, little work has studied the perceptions of young workers regarding safety hazards and incidents.

Young Workers in Agriculture

Generally, production agriculture in the U.S. is located on farms. Typically, these farms are owned and operated by individual and family farm households (USDA, 2009; Hendricks et al., 2005), adding safety management challenges. According to the Fair Labor Standards Act (FLSA, 1938), youth of any age can be employed at any time in any occupation in agriculture, as long as the farm is owned or operated by their parent or a person standing in place of their parent. According to estimates derived from the latest Childhood Agricultural Injury Survey (CAIS), approximately 1.03 million children and adolescents (younger than 20 years) live and work on farms (NOISH, 2010). Another safety challenge on the farm is that it is difficult to separate the work areas from the non-work or living areas. Hence, unlike other industries, the field of agriculture is unique in that not only are the farm operators at risk, but their family members are also exposed to all of the occupational safety hazards on the farm (McCallum et al., 2013).

However, the farm is not the only dangerous agricultural workplace. Young workers in agriculture are also exposed to different risks and hazards than young workers in other industries off the farm (Hard and Myers, 2006; Myers and Adekoya, 2001). Several researchers have observed that young workers in agricultural workplaces incur more serious injuries and a greater proportion of injuries than the young non-agriculture worker population (Hard et al., 1999). Fatality rates of young workers in agricultural operations are three times higher on average than those of young workers in all other industries (Hard and Myers, 2006). Workers in agricultural industries perform multiple seasonal tasks in a short amount of time, often involving physical work, large machinery, and animals (Pfortmueller et al., 2013; Walker, 2010). The long working hours, with high levels of fatigue and sleep deprivation, significantly increase the risk of injury (Lilley et al., 2012). Most of the safety incidents in the agricultural industry follow a predictable pattern and thus can be prevented (Wright et al., 2013), yet employees continue to perform job tasks in an unsafe manner (Walker, 2010). Despite the implementation of numerous programs to improve agricultural safety using engineering and enforcement approaches, fatalities and injuries in the agricultural industry still remain elevated (Karttunen et al., 2013; Pfortmueller et al., 2013).

Safety Management and Safety Climate

One tool often used to measure safety perceptions is safety climate. Originally conceptualized by Zohar (1980), safety climate is an empirical measure of employee perceptions regarding the importance of organizational safety as compared to other organizational priorities, such as productivity or quality. In a more recent study, Zohar (2002) characterized safety climate as a temporary stage of employee perceptions that changes and evolves based on the individuals who occupy the work environment at that given point in time. Although there are subtle variations in the definitions of safety climate across the research literature, all of them suggest that safety climate is a measure of safety perception. Cooper and Phillips (2004) argued that the relationship between safety climate and safety behavior is not as clear cut as commonly assumed. However, the growing body of research in safety climate seems to favor the premise that positive safety perceptions are

significantly linked to lower rates of accidents and injury (Neal et al., 2000; Rundmo, 2000; Zohar and Luria, 2005).

Little previous research has attempted to measure safety perceptions of pre-professional agricultural students. Crowe (1995) and Blair et al. (2004) examined safety beliefs and self-reported safety behaviors of Midwestern college students. Although their studies provided a comprehensive portrait of how college students perceive safety, the perceptions were for safety practices and beliefs across a variety of environments, not just agriculture. Schwab and Freeman (2002) gathered benchmark data for the assessment of safety perceptions and resulting practices as well as baseline knowledge regarding agricultural safety issues as perceived by pre-professional students.

Furthermore, work by Sanderson et al. (2010) suggested that strong safety beliefs and knowledge do not always translate into safe practices. Many pre-professional agricultural students have some agricultural safety background by way of their life experiences, but these experiences are not necessarily positive in terms of safety perceptions and practices (Sanderson et al., 2010). The high-hazard work environment of agriculture coupled with pre-professional workers' safety perceptions and behavior greatly amplifies the risk of occupational injury and death. Yet no comprehensive study exists on the safety perceptions of pre-professional college students in agricultural disciplines, nor has any research examined how perceptions may differ across agricultural disciplines. This research aims to address some of these research gaps.

Quality Management in Agriculture

Although the concepts of quality management are extensively used in many industries, these ideas are relatively new to the agricultural industry (Hurburgh and Lawrence, 2003). The quality of agricultural products is not an absolute concept but rather a complex definition that includes production processes and environmental aspects in addition to nutritional and taste aspects (Barreira et al., 2009).

The increasing occurrence of food contamination outbreaks has resulted in governments imposing new legislation to improve agricultural product quality (Beulens et al., 2009), and quality management is one mechanism identified to facilitate compliance with the legislation (Laux and Hurburgh, 2010). Preliminary research on the use of quality management systems in an agricultural setting has demonstrated several benefits, including increased operating efficiency, improved ability to meet customer requirements, tighter food security control, and greater compliance with new regulations (Laux, 2007; Laux and Hurburgh, 2010). Despite the increased emphasis on quality management in agriculture, pre-professional students in the College of Agriculture and Life Sciences have very little formal coursework in quality. This work aimed to collect baseline data on the knowledge that pre-professional students in agriculture have on agricultural quality and its use as a possible tool for mitigating the probability of safety incidents and safety events.

Link between Safety and Quality

Researchers from several academic areas have noted the importance and interaction of safety and quality in the workplace. One of the first contributors was Dumas (1987), who

concluded that safety is a dimension of quality, since elimination of defects includes the elimination of unsafe practices. Krause and Hidley (1989) found that quality improvement and accident prevention are not only compatible but essentially the same in their goals and approach. According to researchers, quality management concepts have shown a significant positive effect on safety management performance (Das et al., 2008; Levine and Toffel, 2010). In an empirical study to examine the impact of ISO 9001 quality management systems on employee health and safety, Levine and Toffel (2010) noted that companies that adopted ISO-based quality systems had far lower fatalities when compared with non-ISO firms within their industry. They suggested that applying tools of continuous quality improvement, such an ISO-based quality system, can greatly improve occupational safety (Levine and Toffel, 2010).

Das et al. (2008) took exploratory steps toward understanding the role of safety perceptions in quality outcomes. They suggested that motivational theory can explain safety behavior, which forms the link between safety and quality. In a data-based evaluation of the relationships between occupational safety and operational performance, Veltri et al. (2007) suggested that safety and operating performance measures, such as quality, are closely tied.

Previous research within agricultural environments has also suggested a connection between safety and quality. In one such study, Freeman et al. (1998) reviewed grain engulfments at commercial grain elevators and found that low-quality grain increased the level of safety concerns. Similarly, Roberts and Field (2010) noted a positive relationship between out-of-condition grain and the probability of engulfment. In a more recent study, Mosher et al. (2012) further explored these practical connections by collecting survey data on safety and quality climate from employees in an agricultural workplace. The strong association between safety and quality noted in their responses provided empirical evidence of the positive relationship between the safety climate and quality climate perceptions of employees.

Although a correlation between low agricultural quality and occupational safety risk has been documented (Freeman et al., 1998; Roberts and Field, 2010; Mosher et al., 2012), college students may not be aware that the two concepts are associated. These pre-professionals will be on the front line in the development of interventions to manage and eliminate safety hazards and incidents in the agricultural industry as well as manage quality. Yet very little research has examined how these future workers in the agricultural industry perceive the relationship between quality and safety.

Methodology

This work builds on the work of Mosher et al. (2012) and adds to the limited research on pre-professional perceptions of the impact of quality management systems on safety hazards and incidents. In this study, safety hazards are defined as any source of a potential or existing condition in the workplace that can result in injury, illness, property damage, or other losses (CCOHS, 2014). A safety incident is defined as an unplanned, undesired event that has the potential to adversely affect completion of a task and result in personal injury

and/or damage to property, equipment, or the environment (OSHA, 2014). This research project was guided by the following questions:

1. Does a student's rating of the impact of quality management systems on safety hazards and incidents differ based on the student's age group?
2. Does a student's rating of the impact of quality management systems on safety hazards and incidents differ based on the student's gender?
3. Does a student's rating of the impact of quality management systems on safety hazards and incidents differ based on the student's grade classification (freshman, sophomore, junior, or senior)?
4. Does a student's rating of the impact of quality management systems on safety hazards and incidents differ based on the student's field of study?
5. Does a student's rating of the impact of quality management systems on safety hazards and incidents differ based on where the student spent most of his or her childhood (farm, town, or large city)?

Measurement of Data

A widely accepted approach to measuring safety climate is the use of a self-administered questionnaire (Flin et al., 2000; Guldenmund, 2000, 2007). Self-administered questionnaires are a valuable tool in social sciences research as they can be easily distributed among large groups of people in a relatively short period of time (Guldenmund, 2000, 2007).

To investigate the pre-professionals' perceptions of the impact of quality on safety hazards and safety incidents, a survey instrument was designed following the tailored design method (Dillman, 2000). Development of the questionnaire involved a multi-step process. A multidisciplinary systematic review of previous research in safety climate (Schwab and Freeman, 2002; Zohar and Luria, 2005; Johnson, 2007), quality climate (Barreira et al., 2009; Shipton et al., 2008), and safety and quality relationships (Mosher et al., 2012) was conducted. The examined research was evaluated based on the following criteria to identify the most relevant research studies: safety and quality climate studies in academic settings, or safety and quality climate studies in agricultural settings.

The studies by Schwab and Freeman (2002) and Mosher et al. (2012) met these criteria. Schwab and Freeman (2002) examined safety perceptions of students in the Agricultural Systems Technology (AST) major at a large Midwestern public university. Their safety climate survey instrument successfully collected baseline data over a period of eight years, thus allowing them to gain an understanding of AST students' perceptions of agricultural hazards and practiced safety behavior. The questionnaire developed by Schwab and Freeman (2002) also collected demographic information on the students.

The work by Mosher et al. (2012) examining the interaction between safety and quality climate was conducted in an agricultural setting. In their study, Mosher et al. (2012) used two survey instruments: one to measure safety climate, and the other to measure quality climate. The safety climate instrument used by Mosher et al. (2012) to measure employees' safety perceptions at three grain handling facilities was previously developed and validated

by Zohar and Luria (2005) and further validated by Johnson (2007).To measure quality climate, Mosher et al. (2012) constructed a survey instrument based on the validated safety instrument of Zohar and Luria (2005), with some modifications to better align with quality.

To construct a survey instrument for this study, the safety climate instrument used by Schwab and Freeman (2002) was used as a starting point. To incorporate the quality aspect, the safety items in Schwab and Freeman (2002) were used. For each group of hazards, participants were asked how quality management practices would impact the incident and the presence of the hazard in the agricultural workplace. A set of questions was added to capture demographic information on the survey participants, such as age group, gender, year in college (grade classification), and ethnicity. Information on the students' fields of study was drawn from a list provided by the registrar's office, with student identification information manually matched to each student's major. The measurement scales used in this questionnaire were the same as the scales used in the safety climate instrument of Schwab and Freeman (2002).

The questionnaire was pilot tested by administering it to the 45 undergraduate senior-year students in the College of Agriculture and Life Sciences who had filed for graduation in the summer 2013 semester. Based on the responses to the survey in the pilot study, minor modifications were made to increase the clarity of the survey instrument.

The final version of the questionnaire consisted of 17 statements, organized by the sections shown in table 1. A variation of the five-point Likert scale was used in the survey questionnaire to measure students' perceptions. Survey participants specified their level of agreement with a statement or question by choosing one of the five options.

The first section of the questionnaire consisted of only one question requiring participants to declare if they were 18 years or older, the minimum age criterion for participating in the survey. The second section, consisting of five questions, collected demographic information from the participants, such as their gender, age group, current grade classification (year in college), ethnicity, field of study, and the environment where they spent most of their childhood.

The agricultural experience section consisted of four questions asking the participants if they had prior work experience in the agricultural industry and to detail their level of work experience. The participants were also asked to qualify their agricultural work experience and expertise in managing safety and quality by choosing one of five options on the Likert scale. The awareness and knowledge section consisted of four questions. The opinion on safety and quality section consisted of one question with four sub-statements. Participants were asked to provide their opinion on issues related to occupational safety and quality practices in the agricultural industry.

The two sections in the questionnaire measuring the impact of quality management systems on safety hazards and safety incidents each consisted of one question with 12 subparts. The participants were asked to rate the impact of quality management systems by choosing options, ranging from low or no impact to high impact, for each of 12 safety hazards and by

choosing options, ranging from little or no reduction to significant reduction, for each of 12 safety incidents.

The questionnaire used in this study was reviewed and declared exempt from further human subjects review by the university's Institutional Review Board. To administer the survey questionnaire in the pilot test process as well as the final version, the web-based application Survey Monkey (www.surveymonkey.com) was used. The questions asked as part of the study are shown in the following section.

Survey Questions

The initial questions were used to determine the minimum age qualification and demographic information of the participants. The questions related to agricultural experience, awareness and knowledge, impact of quality management on safety hazards, opinion on safety and quality, and impact of quality management systems on safety incidents all used a five-point Likert scale to measure responses (table 2).

Participants

The survey was sent to all undergraduate students enrolled in the College of Agriculture and Life Sciences of a large Midwestern public university for the fall semester in 2013. In this case, "college" refers to an administrative unit within a larger, comprehensive research institution that focuses on the delivery of undergraduate and graduate degree programs in the field of agriculture. The list of enrolled students for fall 2013 was obtained from the registrar's office and showed 4,035 students enrolled in 14 academic departments and 28 degree programs (majors) administered by the College of Agriculture and Life Sciences. These academic departments included:

- Agricultural and biosystems engineering
- Agricultural education and studies
- Agronomy
- Animal science
- Biochemistry, biophysics, and molecular biology
- Ecology, evolution, and organismal biology
- Economics
- Food science and human nutrition
- Genetics, development, and cell biology
- Horticulture
- Natural resource ecology and management
- Plant pathology and microbiology
- Sociology
- Statistics.

Prior to the actual survey questionnaire, all participants were sent a pre-survey notification e-mail stating that they could expect a survey questionnaire in the next few days. Dillman (2000) recommended sending a pre-survey notification to all participants a few days before sending a survey questionnaire to generate a better response rate. Two days after the notification e-mail, the survey questionnaire was sent to all participants using Survey Monkey. Along with the survey questionnaire, a consent letter was sent to all participants explaining the purpose and aim of the study and informing the participants that involvement in the study was completely voluntary. Participants were encouraged to ask clarifying questions about the survey questionnaire. Participants were also provided with technical assistance in case any difficulty arose with the web-based delivery.

Results

Survey Statistics

The survey questionnaire was sent to 4035 undergraduate students enrolled in the College of Agriculture and Life Sciences at the university, and 1017 responses were received, with 933 usable for data analysis. The response rate of 23.1% reflected the rate of usable responses returned. Distribution of participants who responded to this survey questionnaire was found to be representative of the undergraduate student population in the College of Agriculture and Life Sciences.

About 61% of the participants who responded were female students, while 39% were male students. Classification of students was evenly distributed, with 28% of freshman responding, 20.1% of sophomore, 25.3% of juniors, and 25.3% of seniors. About 61% of the participants who responded were in the 18–20 age group, 29% were 21–22 years old, 5% were in the 23–25 age group, and the remaining 5% were older than 25 years.

Approximately 40% of the participants who responded stated that they grew up in a farm environment. More than 75% of the students stated that they had prior experience in agriculture or an agricultural environment. More than 50% of the participants who responded said they had somewhat high or high experience working in agricultural environments. This pattern in the survey data is consistent with what is known about the characteristics of agricultural workers, i.e., that they often begin work at a very young age (McCallum et al., 2013; Wright et al., 2013).

Awareness and Knowledge of Safety and Quality Management

Approximately 96.1% of the participants who responded perceived safety as important or very important in the agricultural industry. However, only 40% of the respondents stated that their level of experience managing safety or quality in agricultural environments was somewhat high or high. This suggests that although the students are aware of the importance of safety and quality in agricultural workplaces, they have very little experience actually managing safety or quality in these environments. These perceptions may partially explain the findings of Sanderson et al. (2010), who noted that a high level of safety experience or knowledge does not always translate to positive safety perceptions and practices.

Impact of Quality Management Systems on Safety Hazards

Approximately 76.5% of the respondents indicated that quality management systems would have a high or fairly high impact on mitigating safety hazards. A smaller number saw no relationship between the two concepts, with only 8.1% of the participants indicating a low or no impact or fairly low impact of quality management systems on safety hazards.

The rating scale used to measure the impact of quality management systems on safety hazards had a range of 1 to 5, where 1 is low or no impact and 5 is high impact. Of the 12 safety hazards, the three with the highest average rating for impact of quality management systems were: contact with anhydrous ammonia (4.32), pesticide exposure or spills (4.29), and suffocation hazards in a grain bin or wagon (4.19). These results indicate that students have a solid understanding of the mitigation potential of quality management on specific safety areas in agriculture, notably in the area of grain safety, as identified by previous authors (Roberts and Field, 2010; Freeman et al., 1998). The three safety hazards with the lowest average rating for impact of quality management systems were: injuries resulting from animals (3.64), injuries caused by a fall (3.71), and gases from manure pits of silos (3.94).

A factor analysis was conducted to more succinctly describe the variability of the pre-professionals' perceptions regarding how quality management systems could influence the reduction of specific agricultural safety hazards. The 12 items used to measure the impact of quality management systems on safety hazards loaded on one factor. This single factor also explained the highest proportion of variance (0.9). This value led to the decision to aggregate individual means for the 12 items into one universal factor to represent the measure of the pre-professionals' perceptions of the impact of quality management systems on the reduction of safety hazards. A new parameter, called "quality on safety hazards," was created in the data set. The value of this parameter is the average of the students' ratings for each of the 12 items measuring the impact of quality management systems on the reduction of safety hazards. The distribution of the "quality on safety hazards" parameter was approximately normal, with a mean of 4.03 and standard deviation of 0.67.

To analyze students' ratings of the impact of quality management systems on safety hazards based on age group, academic classification, field of study, and childhood environment, an analysis of variance (ANOVA) was conducted. To analyze students' ratings based on gender, a t-test was conducted. The results of these tests are shown in table 3.

Impact of Quality Management Systems on Safety Incidents

The data from participants who recorded their perceptions regarding the impact of quality management systems on the reduction of safety incidents had a slightly different distribution. Only 53.2% of the participants perceived a fairly high or high impact, while 12.1% of the participants perceived a fairly low impact or no impact. A little over one third (34.7%) of the students perceived neither high nor low impact. These findings suggest that while students perceive that quality management has potential to mitigate safety hazards, they are unsure if the effect of quality management systems is strong enough to lower the number of incidents that occur.

The rating scale used to measure the impact of quality management systems on safety incidents was the same as that used for safety hazards, with a range from 1 to 5, where 1 is low or no impact and 5 is high impact. Of the 12 safety incidents, the three with the highest average rating for impact of quality management systems were: contact with anhydrous ammonia (4.12), pesticide exposure or spills (4.12), and suffocation hazards in a grain bin or wagon (3.99). Again, the students seem to realize where the management of quality could impact safety, as in the management of pesticides and grain handling. Similarly, the three safety incidents with the lowest average rating for impact of quality management systems were: tractor rollovers (3.64), injuries caused by a fall (3.55), and injuries resulting from animals (3.55).

Again, a factor analysis was conducted to describe the variability of the pre-professionals' perceptions of how quality management systems could prevent specific safety incidents, and the 12 items loaded on one factor. As with safety hazards, a single factor explained the highest proportion of variance (0.9), leading to the decision to aggregate individual means for the 12 items into one universal factor. This factor represents the measure of pre-professionals' perceptions of the impact of quality management systems on the reduction of safety incidents. A new parameter, called "quality on safety incidents," was created in the data set. The value of this parameter is the average of the students' ratings for each of the 12 items measuring the impact of quality management systems on the reduction of safety incidents. The distribution of this parameter was approximately normal, with a mean of 3.87 and standard deviation of 0.8.

To analyze the students' ratings of the impact of quality management systems on safety incidents based on age group, academic classification, field of study, and childhood environment, an analysis of variance (ANOVA) was conducted. To analyze the students' ratings based on gender, a t-test was conducted. The results of these tests are shown in table 4.

Discussion

The first research question asked whether the pre-professionals' perceptions regarding the impact of quality management systems on safety hazards and incidents differed based on age group. The data from this study failed to demonstrate a statistically significant difference in the pre-professionals' perceptions of the impact of quality management systems on both safety hazards and safety incidents based on age group. This finding is noteworthy because previous research suggested that age has a significant effect on safety beliefs and safe behavior (Blair et al., 2004). One reason for the lack of difference in perceptions based on age group could be due to the fact that 91% of the participants were between the ages of 18 and 22 years, and only a small percentage (about 9%) of the participants were age 22 and older. However, in the study by Blair et al. (2004), the majority of the subjects (81%) were also in the age range of 19 to 22 years. Assuming that the perceptions of pre-professionals regarding the impact of quality management systems on safety hazards reflect the students' safety values and safe behavior, the findings of this study do not align with the study by Blair et al. (2004).

The second research question asked whether the pre-professionals' perceptions regarding the impact of quality management systems on safety hazards and incidents differed based on gender of the student. This study demonstrated a statistically significant difference in the perception of the impact of quality management systems on safety hazards and incidents based on gender. The data from this study show that female participants had a stronger perception of the integrative nature of safety and quality than male participants. This finding aligns with previous work by Byrnes et al. (1999), who conducted a meta-analysis of 150 studies in which risk-taking tendencies of male and female participants were compared. Byrnes et al. (1999) suggested that female perceptions of risk were significantly different from that of males, with females generally perceiving risk at a higher level than males. These higher levels of risk perception by females, as documented in previous literature, could also suggest that females perceive factors mitigating these risks at a higher level of effectiveness than do males. This could possibly explain why female students rated quality management as having a higher impact on safety higher than male students in this study.

The third research question asked whether the pre-professionals' perceptions regarding the impact of quality management systems on safety hazards and incidents differed based on the academic classification of the student. This study failed to demonstrate a statistically significant difference in the perception of safety and quality interaction based on academic classification. This finding is also noteworthy, as it does not align with the findings of previous studies. For example, a study by Crowe (1995) on safety values and safe practices among college students showed that academic classification significantly affected safety values, with older students reporting higher levels of safety behavior than younger students. Blair et al. (2004) confirmed the finding by Crowe (1995) that students' safety beliefs explained the greatest amount of variance in their safety behavior, underscoring the importance of a better understanding of how college students perceive safety. The lack of class rank effect on students' perceptions suggests that students pick up limited information that might inform additional safety and quality perceptions even after going through the entire agriculturally based curriculum in the College of Agriculture and Life Sciences.

The fourth research question asked whether the pre-professionals' perceptions regarding the impact of quality management systems on safety hazards and incidents differed based on the field of study of the student. This study failed to demonstrate a statistically significant difference in the perception of safety and quality interaction based on field of study. This finding is also notable, as it does not align with the findings of previous studies. For example, Sun et al. (2014) evaluated food safety knowledge, attitudes, and practices among college students and found that food safety knowledge scores differed based on field of study. Sun et al. (2014) found that medical students, who have exposure to nutrition and health related information as a result of their coursework, have significantly higher scores when compared to students in other majors. Similarly, Tang and Chen (2008), in their study of unethical behavior across college majors, found that students who received ethics intervention significantly changed their conceptions of unethical behavior and reduced their propensity to engage in theft as compared to students who did not receive any interventions. Additionally, Laux et al. (2010) found that students who studied in science-based majors felt more positively about the safety of genetically modified crops. Although field of study seemed to play a role in perceptions related to food safety, ethical behavior, and genetic

modification, no significant differences were noted for the college students surveyed in this study.

Some majors in the College of Agriculture and Life Sciences at the Midwestern public university where this study was conducted require students to complete formal coursework in safety and quality. However, the lack of difference in perceptions based of field of study suggests that the current coursework may be inadequate in preparing these pre-professionals for the safety and quality management challenges of the agricultural industry.

Finally, this study failed to demonstrate a statistically significant difference in pre-professionals' perceptions regarding the impact of quality management systems on safety hazards and incidents based on the childhood environment of the student, which was the focus of the final research question. Childhood environment has been suggested as one antecedent of how safety perceptions are formed, with farm children having a lower sensitivity to agricultural hazards than children raised in other environments (Darragh et al., 1998; Park et al., 2003). This finding is consistent with the findings of both Blair et al. (2004) and Crowe (1995), who reported that students' geographic region had no significant effect on their safety beliefs, safety values, and practices. The findings are also consistent with the conclusions of Davidson et al. (2013) on the use of off-road vehicles. Davidson et al. (2013) concluded that even though there is a difference in the use of off-road vehicles based on urban versus rural status, there is very little difference in helmet use by riders in urban versus rural locations. In other words, there is little evidence of differences in risk perception and behavior based solely on urban or rural upbringing. It appears that the same is true in the interaction of safety and quality.

Conclusion

Several limitations concerning this research should be noted. First, data were collected from one group of students at one university in one region of the U.S. This limits the ability to generalize the findings to a larger population. Extending this study to students in other Colleges of Agriculture and Life Sciences at other universities would substantially strengthen the conclusions of this study. Another limitation of this research was that the subjects provided information voluntarily, inducing a potential for selection bias, as participants who feel strongly about safety and quality could have participated in this study at higher levels than those who felt more neutral about the topic.

Another potential limitation is the assumed level of understanding that the students had concerning the safety hazards. We recognize that variation likely existed in how the students understood and interpreted agricultural safety hazards, but the level of this variation was not measured, nor is it known. The potential variation in the level of student understanding could have influenced the final outcome of the study.

This study was designed as a pilot study and can assist in further research measuring the interaction of safety and quality interactions in agriculture. The findings from this research suggest that pre-professionals perceive an association between quality and safety, just as employees in the agricultural industry did, as observed by Mosher et al. (2012). However,

more work is needed to understand how students gain their awareness of this connection, despite limited classroom training in safety and quality management. Another question raised by this research is the difference between student perceptions regarding the influence of quality management systems on mitigating safety hazards as compared to mitigating safety incidents. Although the safety beliefs about safety hazards and their link to quality management are clearly in place for these students, the lower level of association for the effect of quality management on the prevention of safety incidents is not well understood. Further research in this area of disconnect is warranted. Another area of future research should expand the study to students in other disciplines to explore if their perceptions are similar to or different from those of students in the College of Agriculture and Life Sciences.

This study used a survey instrument to measure the interactions between safety and quality perceptions of pre-professionals. Further research can explore non-survey, qualitative techniques to measure pre-professionals' perceptions. This study demonstrates that although agricultural students have an awareness of safety and how it interacts with quality, further development of this awareness is needed regarding how the two concepts can interact as a safety mitigation tool. The importance of the interaction of agricultural safety and quality must be a part of future agricultural curriculum development so that new agricultural professionals can be prepared to meet the needs and challenges of agriculture in the 21st century.

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Table 1.

Questionnaire sections.

Areas of Interest	Number of Questions
Age validation	1
Demographics	5
Agricultural experience	4
Awareness and knowledge	4
Impact of quality management systems on safety hazards	1
Opinion on safety and quality	1
Impact of quality management systems on safety incidents	1
Total number of questions	17

Table 2.

Summary of survey questions.

Area of Interest	Question
Demographics	What is your gender? What is your grade classification? Please describe the environment where you spent most of your childhood. Please describe your ethnicity.
Agricultural experience	Do you have experience working in agriculture or an agricultural environment? What experience do you have working in an agricultural environment? What experience do you have with the management of safety in an agricultural work environment? What experience do you have with the management of quality in an agricultural work environment?
Awareness and knowledge	How would you rate your level of awareness regarding the management of safety within the field of agriculture? How would you rate your level of awareness regarding the management of quality within the field of agriculture? How important is it to follow safety work practices in the agricultural industry? How important is it to follow established quality management practices in the agricultural industry?
Impact of quality management systems on safety hazards	Please rate the potential impact of quality management systems on the reduction of safety hazards from the items listed: • Tractor rollovers. • Injuries caused by a fall. • Catching clothing on a power take off (PTO). • Electrocution hazards. • Pesticide exposure or spills. • Contact with anhydrous ammonia. • Suffocation hazards in a grain bin or wagon. • Fire hazards. • Injuries resulting from animals. • Air quality in confined building. • Gases from manure pits or silos. • Health problems resulting from grain, dust, or mold.
Opinion on safety and quality	Please indicate your level of agreement with the following statements: • The concept of quality in the agricultural industry is as simple and clear as it is in a manufacturing environment. • Young adults and students in the agricultural industry are not well versed in quality management concepts. • Occupational safety levels in agricultural industries impact the level of quality practices within a workplace. • Age and experience impact quality practices.
Impact of quality management systems on safety incidents	How might quality management systems reduce the risk of the following safety incidents in an agricultural environment? • Tractor rollovers. • Injuries caused by a fall. • Getting clothing caught in PTO unit. • Electrocution. • Pesticide exposure or spills. • Injuries with anhydrous ammonia. • Suffocation in a grain bin or wagon. • Fire. • Injuries from animals. • Health problems caused from air in confined building. • Gases from manure pits or silos. • Health problems caused by grain, dust, or mold.

Table 3.

Hypotheses testing impact of quality management systems on mitigation of safety hazards.[a]

Hypothesis	Analysis	p-Value	R^2	Conclusion
No difference based on age group	ANOVA	0.2111	0.0064	Fail to reject
No difference based on gender	t-test	<0.0001	0.0179	Reject
No difference based on classification	ANOVA	0.1938	0.0066	Fail to reject
No difference based on field of study	ANOVA	0.2026	0.005	Fail to reject
No difference based on childhood environment	ANOVA	0.4689	0.005	Fail to reject

[a] $N = 922$; $\alpha = 0.05$.

Table 4.

Summary of hypotheses testing quality management systems mitigation on safety incidents.[a]

Hypothesis	Analysis	p-Value	R^2	Conclusion
No difference based on age group	ANOVA	0.0502	0.0103	Fail to reject
No difference based on gender	t-test	0.0113	0.007	Reject
No difference based on classification	ANOVA	0.1561	0.0072	Fail to reject
No difference based on field of study	ANOVA	0.5874	0.026	Fail to reject
No difference based on childhood environment	ANOVA	0.0724	0.011	Fail to reject

[a] $N = 918$; $\alpha = 0.05$.