Pesticide safety behaviors and resources utilized among Midwest college students

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PESTICIDE SAFETY BEHAVIORS AND RESOURCES UTILIZED AMONG MIDWEST COLLEGE STUDENTS

By

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To my significant other, Tiara Van Gerpen, my parents, Bob and Julie Soupene, and my sister, Tia Soupene.

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ABSTRACT

Although pesticides are widely used in agriculture throughout the midwestern United States, they are considered an occupational hazard. Pesticide safety training and personal protective equipment (PPE) are used to reduce pesticide exposure; however, little is known about whether young agricultural workers receive training, utilize methods to control exposure, and understand their roles in the pesticide application process. Furthermore, little is known about what information resources they utilize to find information about pesticides and whether risk-taking attitudes may impact safety behaviors of young agricultural workers. A survey was conducted to address these gaps. Young agricultural workers were recruited through three collegiate agricultural programs. Among all study participants (n=106), 35.8% had experience applying pesticides with most (65.8%) applying pesticides two or more times in the past year. Most participants who applied pesticides reported receiving pesticide training (76.3%), always wearing gloves (60.5%), and always wearing long pants (76.3%). Most participants also reported never wearing respirators (44.7%) or protective suits (52.6%), but this is likely due to the types of pesticides used and methods of application that do not require these forms of PPE. Almost half (47.4%) were never responsible for making the decision to apply; rather, parents (36.8%) and employers (35.1%) made the decision to apply. Among all participants, the internet was the most utilized source to find information about pesticides (76.4%), with the most common internet resources being university or college (71.6%), the government (69.1%), or pesticide companies (66.7%). Accessibility (90.6%) and speed (78.3%) were the most common reasons for using the internet for information. Misinformation was the most common barrier (80.2%). No statistical significance was found when comparing risk-taking attitudes and safety behaviors. Although findings were limited by sample size, this study was the first step in identifying

pesticide safety practices employed (e.g., glove use) by young agricultural workers and how they use the internet for pesticide information. Future studies should continue to examine how young agricultural workers utilize pesticide safety and acquire pesticide information.

PUBLIC ABSTRACT

Pesticides are agrichemicals utilized in the midwestern United States for crop protection. Despite their usefulness, pesticides are considered an occupational hazard. Pesticide safety practices including wearing personal protective equipment (PPE), receiving pesticide safety training, and seeking information about pesticides to protect worker safety and health. However, little is known about how these practices are used by young agricultural workers. Additionally, little is known about how risk-taking attitudes may influence pesticide safety behaviors among young agricultural workers. A survey was conducted among college students in the midwestern United States to fill these research gaps.

While only around a third of participants (35.8%) had experience in applying pesticides, most who did have experience reported applying pesticides two times or more (65.8%) in the past year. Additionally, individuals with pesticide application experience utilized safety practices including always wearing gloves (60.5%), always wearing long pants (76.3%), and receiving pesticide training (76.3%). Most individuals reported never wearing respirators (44.7%) or protective suits (52.6%) were never worn, but this is likely due to the types of pesticides used and the methods of application which do not require these forms of PPE. Approximately half do not make the decision to apply pesticides (47.4%), this is decision is typically made by the parent (36.8%) or employer (35.1%). The internet was the source most frequently used to find information about pesticides (76.4%) with the most common online resources being a university or college website (71.6%), the government website (69.1%), or online materials from a pesticide company (66.7%). Reasons for using the internet included accessibility (90.6%) and speed (78.3%). Misinformation (80.2%) was the largest barrier for not using the internet. Lastly, there was no association between risk-taking attitudes and safety behaviors. These findings are

the first step in identifying pesticide safety practices used by young agricultural workers and how the internet is employed to find information about pesticides.

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CHAPTER I: INTRODUCTION

Agricultural Pesticide Use

Agriculture is one of the most dangerous industries in the United States (NIOSH, 2020a). According to the Bureau of Labor Statistics (BLS), 573 agriculture, forestry, and fishing (AFF) workers died from a work-related injury in 2019, a rate of 23.1 deaths per 100,000 workers (BLS, 2019a). Nonfatal occupational injuries and illnesses in 2019 were approximately 2.8 per 100 full time agricultural workers (BLS, 2019). Moreover, the National Institute for Occupational Safety and Health (NIOSH) indicates that roughly 100 agricultural workers will be injured in a way that requires time off or loss of worktime each year (NIOSH, 2020a). Injuries in agriculture occur due to workplace hazards, including pesticides.

Pesticides are a category of chemical compounds used for the mitigation of pests, such as insects, weeds, and fungi. Approximately 4.1 million tons of pesticides are applied every year around the world and this total is estimated to have increased by almost 50% during the last two decades (Gu, 2019). In the United States, over 400,000 tons of pesticides were applied, primarily in agriculture (FAO, 2020). Agricultural use of pesticides and application methods vary by both location and crop. For example, farms in Iowa are some of the largest corn and soybean producers in the country and approximately 50% of farms harvest corn and/or soybeans in Iowa (USDA, 2018). These crops are vital to Iowa's economy and pesticides are essential to producing a successful crop (IDALS, 2021). According to a USDA 2018 report on chemical use in corn and soybean agriculture, the total annual amounts of pesticides (e.g., insecticides, herbicides, and fungicides) applied to corn and soybeans in Iowa were approximately 274,000 pounds and 283,000 pounds, respectively. Herbicides were applied to 95% of the corn planted, with fungicides (32%) and insecticides (18%) applied to a smaller percentage of the crop. Similarly, herbicides were applied to almost 100% of soybeans planted, and fungicides and insecticides were both applied to about 19% of the crops (USDA, 2019). Herbicides are applied more often to prevent growth of plants (e.g., weeds), whereas other types of pesticides are applied following pest emergence (Todd, 2010). These statistics demonstrate the widespread use of pesticides applied in Iowa agriculture and the potential for pesticide exposure to agricultural workers.

Information about pesticide application methods, including mixing and applying, are available from multiple sources (Ozkan, 2020; ISU, 2021). A primary resource for pesticide applicators is state extension programs. Housed at land-grant universities, agricultural state extension offices were created to address contemporary environmental risks, perform field research, and provide educational resources to individuals and the community (Bennett, 1996; ISU, 2021). For example, Iowa State University (ISU) Extension and Outreach provides several resources for pesticide applicators and farmers in Iowa to learn more about the pesticide application process (e.g., seed treatment, certified handlers, ornamental and turf applicators) (ISU, 2021). These resources indicate the complexity of applying pesticides to different crops, but also describe general principles farmers can use to decide what pesticides to apply (e.g., identifying the pests, selecting pesticides designed to mitigate a specific pest) and instructions on how to approach certain steps in the pesticide application process (e.g., best nozzle type for application, maximizing pesticide coverage) to reduce exposure (Ozkan, 2020). State extension programs also provide resources describing the pesticide application process, including information about seed treatments, handling pesticides, and safety (ISU, 2021). These resources are important to states like Iowa whose economies depend on agriculture (USDA, 2019).

Agricultural Pesticide Use in Iowa

While recommendations are available on how to mix and apply pesticides, less is known about the specific methods used by pesticide applicators or farmers in Iowa. One prospective cohort study found corn and soybean crops in Iowa require a large amount of pesticides to be applied compared to other types of crops (Alavanja, 1999). Although pesticide applicators and farmers can use several methods to apply pesticides, the most common method was to use a tractor to pull a pesticide sprayer or using a self-propelled sprayer (Alavanja, 1999). Other application methods include the use of hand-held sprayers on small fields of crops (e.g., vegetables) or aerial applications. Farmers may also hire a contractor to apply pesticide to their fields.

To better understand how agricultural workers are exposed to pesticides in Iowa, Reynolds et al., (2007) examined the use of agrichemicals, including pesticides, among farmers and non-farmers in a rural Iowa county. The study found that approximately 33% of participants had personally mixed or applied farm chemicals at some point during their lifetime. In addition, individuals who mixed or applied pesticides in the previous year had used herbicides (49%), insecticides (48%), and/or fungicides (9%). While this study provides some awareness of how many individuals may be involved in applying pesticides or what types of pesticides are being applied in Iowa, this study is limited to one county (Reynolds, 2007).

Curwin et al. (2002) sought to examine pesticide use and practices in Iowa by administering a questionnaire to 25 farm homes and 25 non-farm homes. This study found that the majority of farmers grew corn and about half grew soybeans, and most farmers applied pesticides themselves (instead of hiring a contractor). In addition, approximately half of all farm operations had children under 16 living on the farm who were involved in agricultural work.

These findings indicated that farmers and children may be exposed to pesticides due to their involvement on the farm and the prevalence of pesticide use in corn and soybean production (Curwin, 2002). Although this study provides information about farming operations in Iowa, it was conducted almost two decades ago, and pesticide use has dramatically increased since the data was collected (FAO, 2020).

As preliminary research to inform this thesis, we conducted key informant interviews with nine agricultural professionals in Iowa including pesticide educators, pesticide applicators, and both conventional and organic farmers to better understand current pesticide application methods utilized in Iowa. Methods of application were similar among the pesticide applicators and typically included spraying with self-propelled sprayers or tractor hitched sprayers. Additionally, the farmers reported that they typically sought advice from the pesticide dealer about what and when to apply. These findings informed the thesis research by offering insight into how pesticides may be selected and applied in Iowa. (Soupene, unpublished).

Exposure and Health Effects

Despite the benefits of using pesticides in agriculture production (Cooper, 2007), exposure to pesticides can be hazardous to agricultural workers. Occupational exposure can occur through dermal absorption, ingestion, or inhalation. In addition, there is concern about exposures to the fetus when a mother is pregnant, and exposure to children (Gilden, 2010). Specific activities are associated with increased risk of exposure. For example, workers can be exposed to pesticides through spills while mixing, loading or when maintaining or cleaning equipment (EPA, 2021a; Kim, 2017). Workers can also be exposed by entering fields that have recently been treated with pesticides (NPIC, 2020). Agricultural workers and community members may also be exposed through pesticide drift (NPIC, 2020). According to the National Pesticide Information Center (NPIC), pesticide drift is the movement of pesticides from the target area of application to a non-target area (NPIC, 2020). Drift typically occurs due to high winds, spraying with small droplet sizes, or spraying the pesticide too high above the plants. This can lead to exposure to other workers or people not involved in the farming operation (NPIC, 2020).

Exposure to pesticides can lead to short- and long-term adverse health outcomes. According to the Sentinel Event Notification System for Occupational Risk (SENSOR), a state-based surveillance program for acute pesticide-related illnesses in 13 states, over 50% of acute pesticide-related illnesses reported between 1998-2011 were associated with farming (NIOSH, 2020b). In Iowa, 61 reported cases of pesticide poisonings occurred from exposure to disinfectants, insecticides, herbicides, and fungicides in 2012 (Walker, 2013). While reported case numbers are relatively low, pesticide illness cases are often unreported (Prado, 2017). Furthermore, pesticide illness data in Iowa is outdated with the most recent report from 2013 (Walker, 2013). This data may no longer be representative of the current poisoning cases in Iowa, because pesticides and pesticide use continue to change over time.

In addition to acute pesticide poisonings, long-term health outcomes associated with pesticide exposure are also a concern. There are several large-scale efforts, including the Agricultural Health Study (AHS), designed to understand how pesticide exposure is associated with long-term health outcomes, specifically cancer (AHS, 2021; Andreotti, 2020; Lerro, 2021). The AHS is a cohort study which recruited over 89,000 pesticide applicators and their spouses in Iowa and North Carolina between 1993-2015 to examine the association between agricultural exposures, such as pesticides, and cancer. Associations between pesticide exposure and different types of cancer have been found using this cohort (Andreotti, 2020; Lerro, 2021). For example, Andreotti et al. (2020) used participants in the AHS to examine the risk between renal cell carcinoma (RCC) and 38 different pesticides. Associations were found between RCC and four herbicides (2,4,5-T, atrazine, cyanazine, and paraquat) (Andreotti, 2020). Another study found an increased incidence of thyroid cancer in male pesticide applicators who used fungicidal metalaxyl and insecticidal lindane (Lerro, 2021). Other studies have reported associations between pesticide exposure and prostate cancer (Christensen, 2016; Pardo, 2020) and breast cancer (Werder, 2020) using the AHS cohort. Studies that examine pesticide exposure and long-term health effects can be difficult to conduct because chronic health conditions (e.g., cancer) develop over prolonged periods of time. Furthermore, long-term health conditions often result from multiple contributing factors. The AHS provides an opportunity to examine how these associations developed over time.

Pesticide Concerns

A study of Midwest farmers (i.e., Iowa, Missouri, Ohio) examined concerns about hazards in agriculture and found that adult agricultural workers listed agrichemicals as a main health and safety concern (Arora, 2020). These concerns included safety in handling agrichemicals, the effect of these chemicals on health, pesticide drift, and how to use and store chemicals. A similar survey was administered to students enrolled in an agricultural science program at a community college in Iowa. When asked what their main health and safety concerns were on the farm, most participants said they were concerned about acute traumatic injury, respiratory health conditions (e.g., lung injury from dust exposure), and chemical exposures (e.g., pesticides) (Soupene, 2020). These studies demonstrate that agricultural workers in Iowa are concerned about exposure to pesticides.

In our interviews with agricultural professionals to better understand the pesticide application process and identify concerns about pesticides, we found that participants' concerns about pesticide use were conflicting. For example, one farmer claimed that "there are a million ways to die" and that the benefits of using pesticides outweigh their risks. Alternatively, another farmer said pesticides were a major problem in agriculture and described how pesticides were dangerous at all levels. This study demonstrated different levels of concern for pesticides among the participants. However, this study did not provide any information into what specific concerns farmers have regarding pesticides (e.g., pesticide drift to crops, long term health effects). (Soupene, unpublished).

Pesticide Registration and Regulations

All pesticides used in the United States are regulated and registered by the Environmental Protection Agency (EPA). According to the EPA, registering a pesticide is a process that involves examining the pesticide ingredients (both active and inert ingredients), the crops or sites where the pesticide will be used, the frequency of its use, and how to properly store and dispose of the pesticide. As part of the registration process, the EPA evaluates potential adverse human and environmental health outcomes associated with a pesticide through risk assessments. Risk assessments are designed to identify short- and long-term health outcomes in humans and potential environmental impacts, including contamination of surface and ground waterways from runoff, spray drift, and draining (leaching) (EPA, 2021a). Although the EPA must assess adverse health outcomes associated with pesticides, the registration process relies heavily on risk assessments that use unpublished regulatory studies and have therefore not been rigorously reviewed (Benbrook, 2019; EPA, 2021a; Gilden, 2010).

Federal and state statutes are also used to protect applicators and the public from pesticide exposure (EPA, 2021a). At the federal level there are two main statutes that regulate pesticides: the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Federal Food, Drug and Cosmetic Act (FFDCA). FIFRA is the statute that requires registration for all pesticides used in the United States. Additionally, it addresses when restricted or unregistered pesticides may be used in emergency situations; suspends or cancels pesticide registrations based on adverse findings; and establishes training requirements to apply pesticides. FFDCA is the statute that establishes a maximum level of tolerance for pesticides used on food or animal feeds. It also requires more robust stipulations for limiting pesticide residues on food for infants and children (EPA, 2021a). Other laws have been used to amend FIFRA and FFDCA. For example, the Food Quality Protection Act of 1996, which amended both FIFRA and FFDCA, required pesticide registrations to occur at least every 15 years. It also required the consideration of other factors during the pesticide registration process (i.e., susceptibility of adverse health effects to children, aggregate risk from multiple exposures, and chronic exposure). The Pesticide Registration Improvement Act of 2003 required companies to pay service fees and required the EPA to meet deadlines for evaluating a pesticide. It also allowed expedited review periods for lower-risk registration applications. Finally, the Endangered Species Act specified that the EPA must consider endangered or threatened species and their habitats when registering pesticides (EPA, 2021a). These federal laws are in place to protect workers, the public, and the environment from potential risks to pesticide exposure. Additional protective measures are typically managed at the state level.

While the EPA handles all the pesticide regulations, pesticide applicator certification and enforcement of regulations is managed by states. In Iowa, pesticide regulations and certification are controlled by the Iowa Department of Agriculture and Land Stewardship (IDALS). This bureau's purpose is to oversee certification for pesticide applicators (commercial, private, and aerial applicators), investigate cases of pesticide drift, enforce pesticide regulations and penalties, and provide information about pesticide products used in Iowa (IDALS, 2021). In Iowa, pesticide certification is required for an individual to apply restricted-use pesticides or pesticides not available to the public (EPA, 2021a). All pesticide applicators must initially pass a written examination to become certified as a pesticide applicator. After passing the initial examination, they need to be recertified every three years. They can either take a recertification examination, which is like the initial examination, or they can be recertified by taking a continuing instruction course (CIC) each year (ISU, 2021). Our key informant interviews conducted with agricultural professionals, including certified pesticide applicators, indicated that taking the CIC was often "easier and more informative" than retaking the certification examination (Soupene, unpublished). CICs typically present updates on current pesticide regulations, information on how pesticides interact with human and environmental health, and review pesticide application procedures (ISU, 2021).

In addition to requiring the certification of restricted use pesticide applicators, the Agricultural Worker Protection Standard (WPS) is an EPA law that requires workers to be trained on pesticide safety to reduce exposure among agricultural workers and their families (EPA, 2021b). The WPS requires employers to provide annual pesticide safety training, give workers access to information on when pesticides are applied, and provide workers with personal protection equipment (PPE) in good operating condition. While the WPS applies to approximately 2 million agricultural workers in the U.S., farm owners and immediate family members of farm owners are exempt from many of the requirements, including the pesticide safety training requirement and the care of PPE used for pesticide application (EPA, 2021b). In Iowa, approximately 83% of farms are considered family farms (USDA, 2018). Family farms are farming operations that are owned and managed by a family and represent over 95% of farms in the United States (NIFA, 2021). This suggests that most farms in Iowa may not regularly conduct pesticide safety training required by the WPS. It is also unknown how many workers on family farms engage in other behaviors to reduce pesticide exposure (e.g., wearing PPE).

While pesticide applicator certification and the WPS provide information on ways to reduce exposure, administrative controls only offer a certain level of protection. According to a report conducted on work-related pesticide poisonings in Iowa, around 60% of pesticide poisoning cases, including exposure to disinfectants, insecticides, and herbicides, occurred when PPE was not appropriately worn (Walker, 2013). Although the EPA requires pesticide applicator certification and uses the WPS to protect agricultural workers, other individuals may be in the area when pesticides are applied, including farmers and farmworkers. For instance, pesticide drift may expose other workers or bystanders not engaged in the application process to pesticides. Furthermore, training is only effective if the individual utilizes what they learn from the training. Training or administrative controls may often be used but they are not the most effective methods for controlling occupational hazards (NIOSH, 2015). More effective methods of control include the selection of less toxic pesticides and equipment designed to reduce contact with pesticides (e.g., closed tractor cabs, lock and load application systems).

Young Workers

Workers between the ages of 16-24 represent a significant portion of the entire workforce in the United States. Around 19.4 million workers, or about 12% of the workforce, in the United States were under the age of 25 in 2020 (NIOSH, 2020c). Younger workers have higher rates of occupational injuries than older workers (BLS, 2019c; DeWit, 2015; NCCRAHS, 2020; NIOSH, 2020c; Guerin, 2020; Rauscher, 2016). In 2018, the incidence rates of occupational injuries and illnesses was higher for employees between the ages of 16-19 years (111.4 injuries/illnesses per 10,000 full-time) and employees between the ages of 20-24 years (100.9 injuries/illnesses per 10,000 full-time), compared to the total rate for all employees (98.4 injuries/illnesses per 10,000 full-time employees) (BLS, 2019c). Furthermore, occupational injuries treated in the emergency room were approximately 1.25 times higher for workers aged between 15-19 years compared to workers older than 25 (NIOSH, 2020c).

Young workers who work in agriculture in particular are at high risk for fatal occupational injuries and illnesses (DeWit, 2015; NCCRAHS, 2020; Rauscher, 2016). Over 40% of all work-related deaths among workers under the age of 18 occurred in agriculture. Young workers are seven times more likely to have a fatal injury in agriculture compared to all other industries combined (NCCRAHS, 2020). Family farms that have less than 11 employees are considered exempt from labor regulations in the United States (OSHA, 2020; DeWit, 2015). Therefore, children and adolescents can work on farming operations at young ages without any federal safety and health oversight (DeWit, 2015). However, young workers who work on these farming operations represented 87% of the total occupational fatalities between 2001 and 2012 among those who worked on farms with 10 or fewer employees (Rauscher, 2016). When examining years of potential life lost (YPLL), agricultural workers under the age of 18 years represented around half (12,241) of the total YPLL of young workers among all industries combined (Rauscher, 2016).

Young workers in agriculture are exposed to health and safety hazards including pesticides (NIOSH, 2003; Rauscher, 2016). Although young workers must be 18 to apply and mix pesticides, these regulations do not apply to family farms with fewer than 11 employees, despite the Fair Labor Standards Act of 1969 that prohibits children under the age of 16 years to apply pesticides (Smith, 2011). Since most farming operations in Iowa are family farms, this exception may put young workers in Iowa at risk for pesticide exposure and the short- and long-term health consequences (USDA, 2018).

When examining pesticide illnesses in Iowa, the greatest percentage of poisonings occurred among 20–29 year old workers, approximately 30% of all cases (Walker, 2013). While acute pesticide poisoning information shows that young workers may be at-risk, limited studies exist examining how young agricultural workers may be exposed to pesticides (Shipp, 2007). High school students in Texas were surveyed to examine employer compliance with pesticide safety training (Shipp, 2007). In Texas, individuals who are 16 years or older can work with pesticides, including mixing and applying, under the U.S. Department of Labor Fair Labor Standards Act and Texas child labor laws. Although they are required to complete a pesticide safety training course as required by the EPA Worker's Protection Standard (WPS), it is not well understood how rigorously this standard is enforced. The survey found that less than a quarter of the study participants reported ever received training on pesticide safety. (Shipp, 2007) Requirements for agricultural employees are governed by the WPS, but adolescents who are immediate family members to the farm owner may not be required to complete the WPS training (EPA, 2021b).

Young workers in agriculture are at greater risk for occupational injury and illness through exposure to pesticides than other age groups. However, little is known about pesticide safety practices young workers utilize, how often they are trained on pesticide hazards, what pesticide-related issues they are concerned about, and how young workers acquire information about pesticide safety.

Risk-Taking Attitudes and Pesticide Safety Behaviors

Several studies have examined how risk-taking attitudes and safety behaviors associated with pesticide use vary among agricultural workers (Alavanja, 2001; DellaValle, 2012; Harrell, 1995; Pickett, 2017; Sorenson, 2017). Pickett et al. (2017) compared risk-taking attitudes among adolescents (age 11-16 years) who lived or worked on a farm (n=2,939) to others in rural communities who did not live or work on farm (n=26,353). Risk-taking attitudes were judged by examining how behaviors such as smoking, alcohol consumption, and bicycle helmet use was associated school performance and mental health status. Findings indicated that adolescents who lived or worked on the farm engaged in more "risky" attitudes, especially male adolescents (Pickett, 2017). While Pickett et al. (2017) was able to quantify risk-taking attitudes, they did not seek to find associations between risk-taking attitudes and safety behaviors.

Sorensen et al. (2017) coordinated interviews of 93 farmers, farm spouses, and family members to better understand farmer's attitudes towards safety practices on the farm. Participants came from dairy, livestock, row crop, and organic farming operations. Interview questions were designed to understand how farmers' attitudes were associated with safety behaviors. Participants felt that engaging in risk-taking attitudes has value. For example, participants indicated when they needed to get work done quickly and effectively, taking risks, or exposing themselves to a hazard may be necessary to accomplish their objectives (Sorensen, 2017). Both studies suggest that people who work in farming may have more risk-taking attitudes. Nevertheless, both studies fall short of measuring how risk-taking attitudes are associated with safety behaviors on the farm.

Risk-Accepting Personality Assessment

The Risk-Accepting Personality Assessment is a tool that was adapted from Harrell et al. (1995) to better understand how risk-taking attitudes were associated with safety behaviors on the farm (Harrell, 1995; Alavanja, 2001). Harrell et al. (1995) administered a 40-item questionnaire to 683 farmers to examine how risk-taking attitudes toward safety impacted health and safety behaviors on the farm. The study found that individuals who were considered to have more risk-taking attitudes were more likely to have experienced an occupational injury and less likely to wear protective clothing. The study suggested that future studies should examine how risk-taking attitudes impact safety practices due to the influence psychological variables have on safety (Harrell, 1995).

As part of the AHS, Alavanja et al. (2001) adapted five questions from Harrell's study to classify participants as risk-accepting or risk-averse (Alavanja, 2001). Participants in the risk-accepting category were more likely to seek out or participate in behaviors that were considered more dangerous (e.g., not having a rollover protective structure for the tractor, not using PPE when mixing or loading pesticides). Conversely, risk-averse attitudes were associated with individuals who avoid "risky" behaviors (e.g., using PPE when mixing or loading pesticides) (Alavanja, 2001; DellaValle, 2012; Harrell, 1995). A factor analysis found that only four (**Table 1-1**) of the five questions were needed to classify participants into the two categories**.** If participants indicate they somewhat or strongly agree with 3 or more of the questions, they are considered to have a risk-accepting personality; otherwise, they are considered to have a risk-averse personality (Alavanja, 2001).

Table 1-1: Statement questions developed to assess risk-taking attitudes.

Statement Questions (Alavanja, 2001)
Q1 "Farming is more dangerous than jobs in industry or manufacturing."
Q2. "Accidents are just one of the occupational hazards of farming that must be accepted if you are going to be in the business."
Q3. "During a normal work week, it's common for me, while doing farm work, to experience a number of 'close calls' that under different circumstances might have resulted in personal injury or property loss."
Q4. "To make a profit, most farmers take risks that might endanger their health."

This method was used to examine how risk-accepting attitudes were associated with the use of PPE among private and commercial pesticide applicators and their spouses in the AHS cohort. Participants who were in the risk-accepting group were less likely to use PPE compared to participants in the risk-averse group (DellaValle, 2012). While DellaValle et al. (2012) examined the association between risk-accepting attitudes and PPE use, the current study will expand this idea to include other behaviors that can reduce the risk of pesticide exposure (e.g., having an enclosed cab on a tractor and reading the pesticide label).

Pesticides and the Internet

Internet use has increased by adults of all ages over the past few decades. In 2019, approximately 90% of adults in the United States used the internet regularly (Pew Research Center, 2019). Nearly 100% of adults between the ages of 19 and 49 years used the internet compared to 88% of adults between 50 and 64 years and 75% of adults who were 65 years or older. Internet use among younger populations has always been higher than other age groups but over time it has continued to increase to the point that all people less than 30 years of age use the internet to get information (Pew Research Center, 2019).

Studies have examined how younger populations use the internet to find information about health and safety topics (Hanley, 2019; Rohlman, 2013). A literature review found that young adults use online forums to find information and support systems for mental health concerns (Hanley et al., 2019). A study of young workers (14-24 years) found that approximately 70% of participants reported using the internet to find health-related information (Rohlman, 2013). However, we were unable to identify studies that described young worker use of the internet for finding information about pesticides.

Several studies have examined how the internet is used as source of information for pesticides. Rutsaert et al. (2013) conducted an online survey with consumers who purchase pesticides. The survey asked participants about their interest in receiving information about pesticide residues through social media platforms such as Facebook, YouTube, Wikipedia, Twitter, and online forums/blogs. Wikipedia was the platform that most participants preferred to use, and it was considered the most reliable resource compared to the other platforms. More than half of the participants were interested in receiving information about pesticides through social media. Of those who were interested in social media as a resource, about 45% were satisfied with their knowledge on pesticide residues (Rutsaert, 2013). Participants who were interested in using the internet for information tended to be younger and more familiar with social media platforms compared to those who were less interested in using the internet. These outcomes align with data showing that younger people frequently use the internet as a source of health and safety information (Hanley, 2014; Pew Research Center, 2019, Rohlman, 2013; Rutsaert, 2013).

The study by Rutsaert et al. (2013) also asked participants to describe the motives and barriers to using social media for information. Speed and accessibility were identified as important motives for using the internet to gather information (Rutsaert, 2013). However, rural communities have historically had less internet access compared to urban communities in the United States. In 2003, only 50% of rural residents had internet access compared to 67% of urban residents (Gualtieri, 2012). Internet access is growing in Iowa with approximately 81% of residents having internet broadband coverage, and the percentage continues to grow (Tyler, 2021). Furthermore, during the past ten years, cellular phone use has also increased, providing additional options for accessing the internet (Gualtieri, 2012). Lack of trustworthiness was identified as the main barrier for using the internet (Rutsaert, 2013), which has been a growing issue for distributing public health information (Battineni, 2020; Chou, 2018; Cuan-Baltazar, 2020). For example, a literature review found that individuals who use the internet to access health information take into consideration the reliability of a source (Battineni, 2020). However, having limited knowledge about a topic and/or a lack of skill to determine what a reliable source is, can lead to misinterpretations about health information (Battineni, 2020).

One solution to minimizing the perceptions of misinformation is by providing trustworthy resources to the public. Felsot et al. (2002) compared online sources that contained information about pesticide hazards, risks, and policies. Online sources were also ranked based on whether they provided the information needed to conduct a risk assessment for a specific pesticide. Criteria for conducting a risk assessment included ways to identify hazards, information needed to assess a dose-response relationships and exposure assessments, descriptions of risks associated with exposure, and science policy and regulations. In addition, the rating criteria assessed whether citations were included and if current information was available. Felsot (2002) found that besides the EPA website, all information needed for a risk assessment was not available through online sources. Government and university websites were more likely to include citations and current information compared to non-governmental organizations (NGOs). Online resources that lack citations and do not provide enough information contribute to misinformation about pesticides (Felsot, 2002). Nevertheless, the author concluded that using the internet makes finding information on pesticides easier (Felsot, 2002).

Internet use is continuing to increase among all age groups and is becoming a primary source for information. However, little is known about how frequently the internet is used to find information about pesticide-related health and safety for agricultural workers and what reasons and barriers may factor into internet use. Moreover, among internet users, little is understood about what online sources workers use to obtain information about pesticide hazards and safety.

Conclusions

Pesticides are widely used in agriculture for mitigating pests. Despite requirements such as pesticide applicator certification, regulations, and the WPS, they still pose a risk to agricultural workers. Young workers are at risk for pesticide exposure which increases their risk for pesticide-related poisonings and cancer. Since most farms in Iowa are family farms, young workers may not be protected under the WPS and may be engaged in pesticide application at early ages. There are several approaches to reducing exposure to pesticides, such as safety training and the use of PPE. However, it is not well understood what role young workers take in the application of pesticides, whether they receive training, and what safety behaviors they utilize. Furthermore, it is not well understood how risk-accepting attitudes influence safety behaviors such as using PPE or reading the pesticide label. Finally, it is unknown what sources young agricultural workers use to find information about pesticides. This information is needed to understand where young workers receive information and for developing effective ways to distribute reliable information about pesticides.

The goal of this study was to examine pesticide safety behaviors, resources utilized for pesticide information, and attitudes of young agricultural workers in the midwestern United States. This study will be accomplished through the following aims.

Study Aims:

1. Describe the role of young agricultural workers in agricultural pesticide applications and the safety behaviors they utilize.
2. Identify pesticide-related concerns and sources used by young agricultural workers to get information about pesticides (e.g., internet, pesticide labels, television)
3. Examine the association between risk-taking attitudes and safety behaviors related to pesticide application.

CHAPTER II: YOUNG WORKER PESTICIDE SAFETY QUESTIONNAIRE

Introduction

Pesticides are widely used for agriculture in the United States and around the world to limit pest damage, increase crop yield, and to promote food security (Gu, 2018; Cooper, 2007). In Iowa, pesticides are commonly applied to corn and soybean crops. Over 500,000 pounds of pesticides were applied to corn and soybean crops during the 2018 growing season in Iowa. While pesticides have many benefits to agriculture, adverse health effects including acute poisonings and cancer are associated with exposure to pesticides (Cooper, 2007; Walker, 2013; Andreotti, 2020; Christensen, 2016; Lerro, 2021; Pardo, 2020; Werder, 2020).

Several state and federal regulations are in place to protect workers from pesticides. All pesticides must be registered and are regulated under the Environmental Protection Agency (EPA) to evaluate how pesticides may cause adverse health effects to humans and the environment (EPA, 2021a). Additionally, federal statutes such as the Worker Protection Standard (WPS), the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Federal Food, Drug, and Cosmetic Act (FFDCA) are in place to protect agricultural workers from exposure to pesticides (EPA, 2021a). While the EPA handles pesticide registrations and regulations, pesticide applicator certification and enforcement of regulations are up to the state (IDALS, 2021). Pesticide applicator certification requires individuals to take an examination and continually renew their certification through training sessions (IDALS, 2021). These measures are used to protect workers from adverse health effects associated with pesticide application. Furthermore, some farming operations are exempt from parts of these regulations. Immediate family members of the farm owner are exempt from the WPS which requires farming operations to have pesticide safety training (EPA, 2021b). Family farms or farming operations that comprise of immediate family members with less than 11 people are also exempt from inspection (NIFA, 2021; OSHA, 2020). In Iowa, over 80% of farms are considered family farms (USDA, 2018). This exemption puts individuals who work on these farms, such as young workers, at higher risk.

Workers under the age of 25 years represent approximately 12% of the workforce in the United States. Young workers or workers under the age of 25 also have higher rates of occupational injuries, particularly those working in agriculture (BLS, 2019c; DeWit, 2015; NCCRAHS, 2020; NIOSH, 2020a; Guerin, 2020; Rauscher, 2016). Young workers are seven times more likely to have a fatal injury in agriculture compared to fatal injuries in other industries (NCCRAHS, 2020). In Iowa, workers between the ages of 20 and 29 accounted for almost a third of all pesticide poisonings cases (~30%) (Walker, 2013). This finding suggests young workers are at greater risk for pesticide poisoning. While young workers are at greater risk for pesticide poisonings and occupational injuries, little is known about their role in the pesticide application process.

Use of personal protective equipment (PPE) and training on pesticide safety may reduce exposure to pesticides; however, little is known about the role of young workers in applying pesticides, if they receive training, or use PPE when applying pesticides. Risk-taking attitudes have been associated with PPE use (e.g., risk-accepting or risk-averse) (DellaValle, 2012). Preliminary research has found that young workers in Iowa are concerned about pesticides (Soupene et al., 2020), but it is not clear what resources they use to find information about pesticides. The goal of this study was to examine pesticide safety behaviors, resources utilized for pesticide information, and risk-accepting attitudes towards pesticide safety among young agricultural workers in the midwestern United States. This study will be accomplished through the following aims:

Study Aims:

1. Describe the role of young agricultural workers in agricultural pesticide applications and the safety behaviors they utilize.
2. Identify pesticide-related concerns and resources used by young agricultural workers to get information about pesticides (e.g., internet, pesticide labels, television)
3. Examine the association between risk-accepting attitudes and safety behaviors related to pesticide application.

Methods

Participants

Participants were recruited through agricultural programs at two community colleges and one university in Iowa. Participants needed to be between the ages of 18 and 29 and had to have farming experience. Faculty including deans and professors at each institution distributed flyers (**Appendix A**) and/or sent out a recruitment email to agricultural science students at their institution (**Appendix B**). These materials described the purpose of the study and provided a link and QR code to the online questionnaire.

Questionnaire

An online questionnaire contained items addressing demographic information, pesticide safety behaviors, resources that were utilized to obtain information about pesticides, and risk-accepting attitudes towards pesticide safety behaviors. The questionnaire was created using

Qualtrics Survey Software. The online questionnaire began with a letter describing the study and asking participants to select "yes" to participate in the study (**Appendix C).** Next participants were asked to enter their age and years of farming experience. If their age was not between 18 and 29 or they had no farming experience, they were excluded from completing the rest of the questionnaire (**Appendix C**).

The questionnaire included 31 items and used Likert-scale, multiple choice, select all that apply, and open-ended response options. Specific items collected information about demographic information (e.g., age, gender, apply pesticides), pesticide safety behaviors (e.g., reading the pesticide label, use of PPE), types of resources used to learn about pesticides (e.g., internet, pesticide labels), and four questions used to assess risk-accepting attitudes associated with pesticide use. (**Appendix D**).

Participants who reported applying pesticides to the question: *How many years have you been applying pesticides in an agricultural setting?* were asked additional questions about their role in the application process, whether they received training, and specific behaviors they use to reduce exposure to pesticides (e.g., PPE use). They were also asked an open-ended question to describe how the decision is made to apply pesticides at their most recent farming operation.

All participants were asked what resources they use to find information about pesticides and were given a list of responses and asked to select all that apply. Potential resources included the internet, university or college, pesticide dealer, friend or family member, 4-H or FFA, the agricultural extension office, and other. Participants who selected the internet as a resource were then asked additional questions about how often they used the internet to search for information about pesticides and what types of online sites or sources they used (e.g., university, government). All participants were asked how often they used the internet to find general health and safety information.

The final four questions were used to classify participants into either a risk-accepting or a risk-averse group (DellaValle, 2012). The four questions were: Q1. Farming is more dangerous than jobs in industry or manufacturing (Dangerous Industry), Q2. Accidents are just one of the occupational hazards of pesticide application that must be accepted if you are going to be in the business (Accident Fatalism), Q3. During a normal week, it is common for me, while doing pesticide-related work, to experience a few "close calls" that might have resulted in injury/property loss (Close Calls), and Q4. To make a profit, most farmers take risks that might endanger their health (Endanger Health). Response options included strongly agree, somewhat agree, somewhat disagree, and strongly disagree. If a participant strongly or somewhat agreed with three or more of the statements, they were categorized as risk-accepting; otherwise, they were placed in the risk-averse group.

Procedure

Participants used either the questionnaire link or the QR code to access the questionnaire. Upon completion, participants were directed to a follow-up questionnaire (**Appendix E**) to provide contact information to receive compensation. Participants received a $10 check for completing the questionnaire. All study materials and procedures were reviewed and approved by the Institutional Review Board at the University of Iowa. The questionnaire was available between January 18 to February 23, 2021. A follow-up reminder was sent to each faculty member about half-way through the recruitment period asking them to redistribute flyers or send out email reminders to take the questionnaire.

Statistical Analysis

Frequencies and percentages were examined for all categorical variables. Means and ranges were calculated for all continuous variables. Descriptive statistics were provided for those who reported applying pesticides (applicators) and those who did not apply pesticides (non-applicators). Responses from the open-ended question (*Please describe in the text box below how a decision is made to apply pesticides at your most recent farming operation.*) were grouped into categories of similar themes (Terry, 2017). Associations between risk-accepting and risk-averse groups among applicators and demographic information, safety behaviors, and pesticide resources were analyzed using SAS 9.4. Statistical code (**Appendix F)** was developed using previous studies (Gennarelli, 2014; Gould, 2015; UCLA, 2021). Cronbach's Alpha was employed to determine the internal validity of the Likert-scale questions associated with the risk-accepting personality assessment questions. Two-way Wilcoxon-Mann-Whitney Tests were used to examine associations between risk-accepting attitudes and demographic information (e.g., age), pesticide training (e.g., how often participants have received pesticide training) and safety behaviors (e.g., glove use) with numeric and Likert-scale responses. Chi-square tests were used to determine the association between questions with categorical responses (e.g., gender, receiving pesticide training, pesticide applicator certification). The associations between risk-accepting attitudes and safety behaviors were only examined among the applicators.

Results

Demographic Characteristics

Of the 115 participants who started the questionnaire, 106 completed the entire questionnaire and were included in the analysis (92.2% completion rate). Only one participant who completed the questionnaire did not choose to be compensated. Ages ranged from 18-25 with an average age of 19.1 years. **Table 2-1** presents demographic variables for the applicators (n=38) and non-applicators (n=68). Applicators reported working more years in farming (8.3 years, range=18 years) compared to non-applicators (6.6 years, range=19.9 years). Two participants reported 0.1 years of farming experience, indicating that they began farming recently. Eleven participants (10.4%) reported farming 15 or more years, which would indicate they started farming at very young ages. Although, it is unlikely that they were actively engaged in farming at these young ages, it does indicate that these participants had been on the farm and involved in activities their entire life. Pesticide application experience among participants ranged from 1 to 10 years with an average of 2.9 years. Two participants who reported that they had 10 years of pesticide application experience would have been 10 and 13 years old when they started applying pesticides.

Approximately 40% of all participants were female. However, most applicators were male (84.2%). One non-applicator selected “Not Listed” and wrote that gender was not relevant to pesticide application. Most were recruited through community colleges (86.8%). The majority of participants were born in Iowa (90.5%) with others from surrounding states such as Illinois, Minnesota, and Nebraska. Only one participant was born outside the United States. Less than 10% indicated they had any organic farming experience (6.6%) (**Table 2-1**).

Table 2-1: Demographic characteristics among applicators (n=38), non-applicators (n=68), and all participants (n=106).

	Applicators (n=38, 35.8%)	*Non-Applicators (n=68, 64.2%)*	*All Participants (N=106)*
	Mean (Range)		
Demographic Characteristics			
Age (Years)	19.5 (18-22)	19.0 (18-25)	19.1 (18-25)
Years working in farming	8.3 (1-19)	6.6 (0.1-20)	7.2 (0.1-20)
Years applying pesticides	2.9 (1-10)	N/A	N/A
	N (%)		
Gender			
Male	32 (84.2%)	31 (45.6%)	63 (59.5%)
Female	6 (15.8%)	36 (52.9%)	42 (39.6%)
Not Listed	0	1 (1.5%)	1 (0.9%)
College/University			
Community College A	8 (21.1%)	45 (66.2%)	53 (50%)
Community College B	20 (52.6%)	19 (27.9%)	39 (36.8%)
University	8 (21.1%)	4 (5.9%)	12 (11.3%)
Other*	1 (2.6%)	-	1 (0.95%)
Prefer not to answer	1 (2.6%)	-	1 (0.95%)
State of Birth			
Iowa	35 (92.1%)	61 (89.5%)	96 (90.5%)
Illinois	1 (2.6%)	1 (1.5%)	2 (1.9%)
Minnesota	-	2 (3.0%)	2 (1.9%)
Nebraska	-	2 (3.0%)	2 (1.9%)
Other	2 (5.3%)	2 (3.0%)	4 (3.8%)
Organic Farming Experience			
Yes	4 (10.5%)	3 (4.6%)	7 (6.6%)
No	32 (84.2%)	61 (89.5%)	93 (87.7%)
Unsure	2 (55.3%)	4 (5.9%)	6 (5.7%)

*****Other includes: A university or community college not listed in the survey.

Pesticide Application

Participants who reported applying pesticides (applicators) indicated they had applied pesticides primarily to *corn* (42.9%) or *soybeans* (41.6%) (**Table 2-2**). Participants also reported applying pesticides to *grass* (9.1%), *fruit* (2.6%), and *vegetables* (3.9%). The majority of applicators (65.8%) were not certified pesticide applicators. Twelve applicators (31.6%) were certified as either a commercial or private pesticide applicators (one participant was unsure if they were certified). When asked how often they had applied pesticides during the last year, most indicated they had applied two or more times (65.8%) and almost a quarter reported applying once (23.7%). Four applicators reported not applying pesticides during the past year. Over 70% of the applicators reported that their employer (35.1%) or parent (36.8%) were responsible for making the decision to apply pesticides (**Table 2-3**). Additionally, their parent (35.6%) or employer (35.6%) provided training on pesticide safety.

Table 2-2: Pesticide safety and application practices among pesticide applicators (n=38).

Variables/Short Questions	N (%)
Which crops have you applied pesticides to? (Check all that apply)	
Corn	33 (42.9%)
Soybeans	32 (41.6%)
Fruit	2 (2.6%)
Vegetables	3 (3.9%)
Other	7 (9.1%)
Are you a certified pesticide applicator?	
Yes, Commercial	5 (13.2%)
Yes, Private	7 (18.4%)
No	25 (65.8%)
Unsure	1 (2.6%)
During the past year, how often did you apply pesticides?	
Three times or more	13 (34.2%)
Twice	12 (31.6%)
Once	9 (23.7%)
Never	4 (10.5%)
Have you ever received training on pesticide safety?	
Yes	29 (76.3%)
No	9 (23.7%)

Table 2-3: Individuals who are responsible for making the decision to apply pesticides and provide training on pesticide safety (n=38).

	N (%)*	
	Who was responsible for deciding whether to apply pesticides?	*Who provided training on pesticide safety?*
Employer	20 (35.1%)	21 (35.6%)
Parent	21 (36.8%)	21 (35.6%)
Sibling	0	2 (3.4%)
Other Family Member	4 (7%)	4 (6.8%)
Pesticide Contractor	5 (8.8%)	5 (8.5%)
Coworker	5 (8.8%)	5 (8.5%)
Other	1 (1.8%)	2 (3.4%)
Unsure	1 (1.8%)	N/A

*Participants were asked to select all that apply.

When asked about safety behaviors (**Table 2-4**), many applicators reported *always* wearing gloves, using an enclosed cab on the tractor, and wearing long sleeves and long pants. On the other hand, 45% reported *never* wearing a respirator and 53% reported *never* wearing a protective suit. When asked about other protective equipment, responses included wearing hats, close-toed shoes, or safety glasses, and washing themselves after applying. One participant reported not wearing any protection. Approximately 66% of applicators read the pesticide label *always* or *most of the time*. One applicator said they only read the pesticide label if it was a product, they had not used before.

Table 2-4: Number (and percentage) of applicators who use personal protective equipment (PPE) and other methods to control exposure to pesticides (n=38).

Variable	Always	Most of the Time	About Half the Time	Sometimes	Never
Long Pants	29 (76.3%)	6 (15.8%)	1 (2.6%)	1 (2.6%)	1 (2.6%)
Enclosed Cab on Tractor	26 (68.4%)	4 (10.5%)	0	4 (10.5%)	4 (10.5%)
Glove Use	23 (60.5%)	9 (23.7%)	2 (5.3%)	1 (2.6%)	3 (7.9%)
Long Sleeves	15 (39.5%)	7 (18.4%)	3 (7.9%)	6 (15.8%)	7 (18.4%)
Goggle Use	14 (36.8%)	4 (10.5%)	5 (13.2%)	8 (21.1%)	7 (18.4%)
Other Protective Equipment	8 (21.1%)	2 (5.3%)	2 (5.3%)	2 (5.3%)	24 (63.2%)
Protective Suit	8 (21.1%)	1 (2.6%)	5 (13.2%)	4 (10.5%)	20 (52.6%)
Respirator Use	7 (18.4%)	2 (5.3%)	6 (15.8%)	6 (15.8%)	17 (44.7%)
Read the Pesticide Label? [1]	17 (44.7%)	10 (26.3%)	3 (7.9%)	6 (15.8%)	1 (2.6%)

[1] One participant only read the pesticide label it was a product they had never used before.

While more than 60% of applicators *always or most of the time* discuss pesticide safety before handling or applying pesticides, 29% reported only discussing pesticide safety *sometimes* and one reported never discussing pesticide safety (**Table 2-5**). Similarly, more than half of applicators received pesticide safety training *always or most of the time*, while 32% received training only *sometimes*. Three applicators indicated that they had *never* received training. Finally, almost half (47.4%) of the applicators *never* make the decision to apply pesticides.

Table 2-5: Frequency of receiving pesticide training, making the decision to apply pesticides, reading the pesticide label, and discussion of pesticide safety at their farming operation among applicators (n=38).

Variable	Always	Most of the Time	About Half the Time	Sometimes	Never
At your most recent farming operation, how often do/did you talk about safety before handling or applying pesticides?	12 (31.6%)	11 (29.0%)	3 (7.9%)	11 (29.0%)	1 (2.6%)
At your most recent farming operation, how often do/did you receive training before applying pesticides?[1]	11 (29.0%)	9 (23.7%)	2 (5.3%)	12 (31.6%)	3 (7.9%)
At your most recent farming operation, how often are you involved in making the decision to apply pesticides?	5 (13.2%)	5 (13.2%)	6 (15.8%)	4 (10.5%)	18 (47.4%)

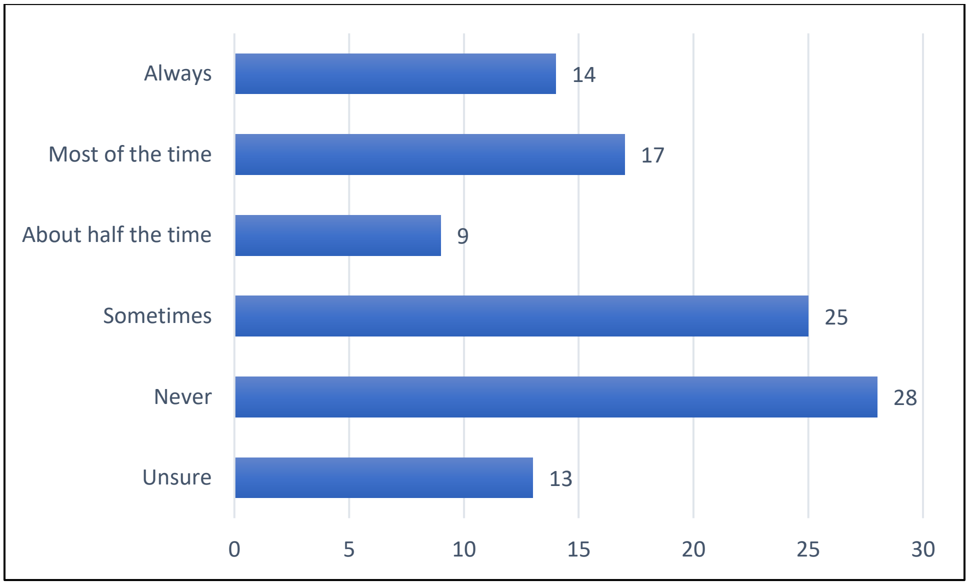
[1] One participant was unsure if they received training about applying pesticides.

The applicators were asked to describe how a decision is made to apply pesticides at their most recent farming operation. Examples of responses included: “my father makes the decision to apply,” “condition of plant,” and “before the bugs ate the plant.” These responses were reviewed and grouped into categories of similar themes (**Table 2-6**). Categories included *individual makes the decision (e.g., employer, family member), in response to pest infestation, protecting against a pest infestation, conditions of the plants,* and *other*. The most common category was *decision made by an individual*. The identified individuals typically were either a parent or an employer. The second most common category was *in response to a pest infestation* with nine responses. Examples of these responses included: “look at crops and determine if it needs it” and “how bad the pests are in the plants.” *Protection against pest infestation* (e.g., “before bugs get to the plants”) and *conditions of the plants* both had four responses. The three *other* responses were “based on equipment”, “based on pesticide/herbicide population, is it above the threshold,” and “talk about the benefits and how much it would affect our farming operation.” Similar to the question asking who makes the decision to apply, most applicators indicated that the decision to apply pesticides is made by an individual (**Table 2-6**). Hiring a contractor to apply pesticides was not common among all participants (**Figure 2-1**); most respondents indicated *sometimes* (N=25) or *never* (N=28).

Table 2-6: Categorized, open-ended responses asking applicators to describe how a decision is made to apply pesticides at their most recent farming operation (n=38).

Category	N (%)
Individual makes the decision (e.g., employer, family member)	18 (47.4%)
In response to pest infestation	9 (23.7%)
Protecting against a pest infestation	4 (10.5%)
Conditions of the plant	4 (10.5%)
Other	3 (7.9%)

Figure 2-1: Frequency of hiring a contractor to apply pesticides among all participants (number).



Concerns about Pesticides

All participants were asked about their pesticide-related concerns. The top two concerns were *pesticide drift to crops* (65.1%) and *water contamination* (62.3%). These were followed by *long-term health outcomes* (43.4%), *pesticide resistance* (46%) and *environmental concerns (40.6%)*. *Food contamination* (29.2%) and *exposure to pregnant women* (22.6%) were the least reported concerns. Participants who said they were concerned about *exposure to pregnant women* consisted of 54% men and 46% women. Only three participants indicated they were not concerned about pesticide-related issues (**Table 2-7**).

Table 2-7: Number and percentage of pesticide-related concerns identified by all participants (n=106).

Areas of Concern	N (%)*
Pesticide Drift to Crops	69 (65.1%)
Water Contamination	66 (62.3%)
Long-term Health Outcomes	46 (43.4%)
Pesticide Resistance	46 (43.4%)
Environmental Concerns	43 (40.6%)
Exposure to Young Children	38 (35.8%)
Pesticide Drift to Homes	36 (34%)
Effectiveness in Eliminating Pests	35 (33%)
Short-term Health Outcomes	31 (29.2%)
Food Contamination	31 (29.2%)
Exposure to Pregnant Women	24 (22.6%)
I am not concerned about Pesticide-Related Issues	3 (2.8%)

*Participants were asked to select all that apply.

Information Resources about Pesticides

Most participants reported using the internet to find information about pesticides (76.4%) with only four participants reporting that they do not look for information on pesticides. In addition to using online resources, participants also sought information about pesticides from universities or colleges (58.5%), pesticide dealers (52.8%), and/or a friend or family member (44.3%). Around a quarter of the participants used 4-H or FFA and the agricultural extension office. The pesticide label was identified as another source of information. (**Table 2-8**).

Table 2-8: Resources utilized to find information on pesticides (n=106).

Resources	N (%)*
Internet	81 (76.4%)
University/College	62 (58.5%)
Pesticide Dealer/Elevator	56 (52.8%)
Friend or Family Member	47 (44.3%)
4-H/FFA	29 (27.4%)
Agricultural Extension Office	28 (26.4%)
Other	3 (2.8%)
I have not looked for information on pesticides.	4 (3.8%)

*Participants were asked to select all that apply.

Participants who selected using the internet as a resource for pesticide information (76.4%) were asked how often they use the internet to find general pesticide information (**Figure 2-2)**. Over half of participants used the internet to find general pesticide information some or half of the time (N=49). Additionally, participants were asked how often they use the internet to find information about health and safety related to pesticides (**Figure 2-3)**. Most participants (N=63) only used the internet *sometimes* or *rarely* to find information about pesticide health and safety. The online sites they reported using included government websites, such as the EPA, university or college websites, and/or pesticide dealer's websites (**Table 2-9**). Less than 15% used social media, non-governmental organizations (NGOs), or news media outlets.

Figure 2-2: Frequency of using the internet to find information about pesticides among internet users (n=81).

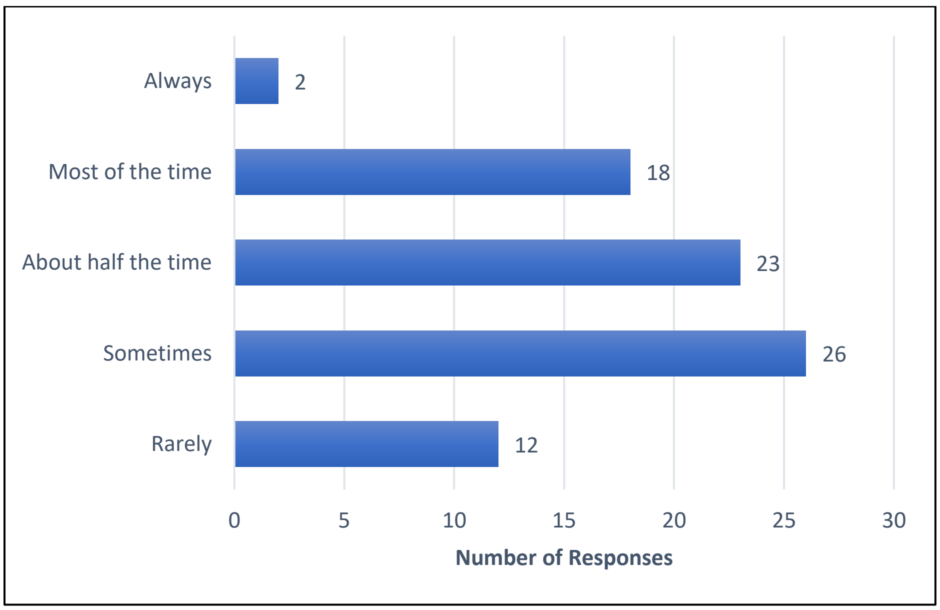


Figure 2-3: Frequency of using internet to find information about health and safety issues among all participants (N=106).

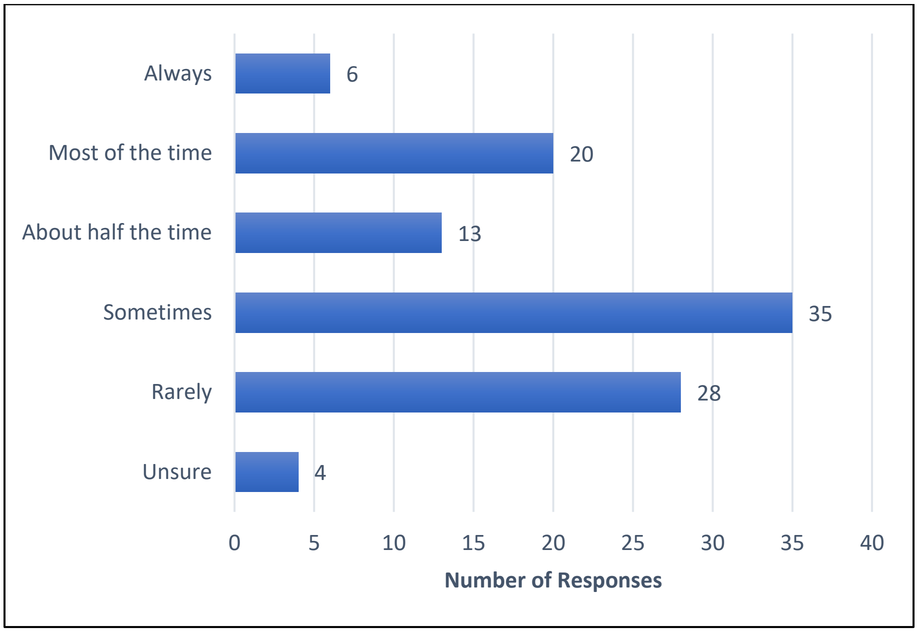


Table 2-9: Type of online sources utilized for information on pesticides (number and percentage) (n=81).

Online Sources	N (%)*
University/College	58 (71.6%)
Government (e.g., EPA)	56 (69.1%)
Pesticide Company (e.g., Bayer CropScience)	54 (66.7%)
Social Media (e.g., Facebook)	11 (13.6%)
Non-Governmental Organization (e.g., Practical Farmers of Iowa)	7 (8.6%)
News Media Outlets (e.g., CNN)	7 (8.6%)

*Participants were asked to select all that apply.

The top three reasons for using the internet among all participants were *accessibility* (90.6%), *speed* (78.3%), and *technological possibilities (e.g., photos, videos;* 46.2%). Only 13.2% of participants reported using the internet for social interaction. Two participants noted that they do not use the internet. *Misinformation* was reported (80.2%) as the largest barrier for using the internet, followed by *competition of traditional media* (36.8%) and it being *time-*

consuming (22.6%). *Speed* (16%) and *accessibility* (8.5%) were the least selected barriers (**Table 2-10**).

Table 2-10: Reasons and barriers for using the internet for information (number and percentage) (n=106).

Motives	N (%)*
Accessibility	96 (90.6%)
Speed	83 (78.3%)
Technological possibilities (e.g., photos, videos)	49 (46.2%)
Social interaction	14 (13.2%)
I do not use the internet	2 (1.9%)

Barriers	N (%)*
Misinformation	85 (80.2%)
Competition of traditional media	39 (36.8%)
Time-consuming	24 (22.6%)
Accessibility	17 (16%)
Speed	9 (8.5%)
Other	2 (1.9%)
I do not use the internet	1 (0.9%)

*Participants were asked to select all that apply.

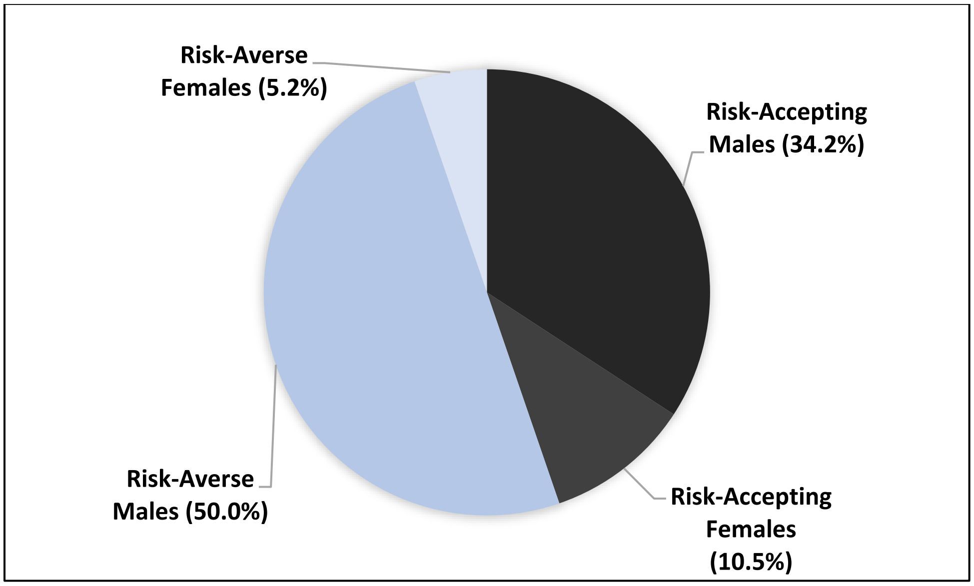
Risk-Accepting v. Risk Averse Comparison

Applicators were grouped into either risk-accepting or risk-averse categories (**Figure 2-4**) based on a four-item scale (DellaValle, 2012). The use of pesticide safety behaviors was then compared between these two groups. Applicators were grouped based on their responses in **Table 2-11** into risk-accepting or risk-averse. If participants *somewhat* or *strongly agreed* with three or more of the items, they were categorized as risk-accepting; otherwise, they were categorized as risk-averse. Slightly more applicators (55%) were included in the risk-averse category, whereas 45% were included in the risk-accepting category (**Figure 2-4**). Although only six applicators were female, two-thirds were categorized as risk-accepting compared to 41% of the males (**Figure 2-4**).

Table 2-11: Distribution of responses to risk-accepting attitudes among all participants (n=38).

Variable	Level	N (%)
Q1. Farming is more dangerous than jobs in industry or manufacturing. (Dangerous Industry)		
	Strongly Agree	11 (28.9%)
	Somewhat Agree	23 (60.5%)
	Somewhat Disagree	4 (10.5%)
	Strongly Disagree	0
Q2. Accidents are just one of the occupational hazards of pesticide application that must be accepted if you are going to be in the business. (Accident Fatalism)		
	Strongly Agree	12 (31.6%)
	Somewhat Agree	12 (31.6%)
	Somewhat Disagree	11 (28.9%)
	Strongly Disagree	3 (7.9%)
Q3. During a normal week, it is common for me, while doing pesticide-related work, to experience a number of "close calls" that might have resulted in injury/property loss. (Close Calls)		
	Strongly Agree	6 (15.8%)
	Somewhat Agree	3 (7.9%)
	Somewhat Disagree	14 (36.8%)
	Strongly Disagree	15 (39.5%)
Q4. To make a profit, most farmers take risks that might endanger their health. (Endanger Health)		
	Strongly Agree	11 (28.9%)
	Somewhat Agree	13 (34.2%)
	Somewhat Disagree	8 (21.1%)
	Strongly Disagree	6 (15.8%)

Figure 2-4: Distribution of male and female applicators into risk-averse and risk-accepting categories (n=38).



Cronbach's alpha was used to examine the reliability of the four items used for determining risk-accepting attitudes among the applicators. A Cronbach's alpha of 0.7 or greater demonstrates an acceptable consistency (Tavakol, 2011). The Cronbach's alpha was 0.825510, indicating that the questions were internally consistent. There were no statistically significant differences between the groups on demographic information, pesticide activities, safety behaviors, and pesticide resources and risk-accepting attitudes (**Table 2-12**). Categorical data not included in **Table 2-12** such as gender, receiving pesticide training, and having a pesticide applicator certification were also not significant. This lack of statistical significance may be due to small sample size. (**Table 2-12**).

Table 2-12: Wilcoxon-Mann-Whitney scores of risk-averse and risk-accepting groups over demographic characteristics, acquiring information, and hiring a pesticide contractor among all participants (n=38).

	Risk-Averse Group (n=21)	***Risk-Accepting Group (n=17)***	
Variable:	**Mean (Standard Deviation)**	**Mean (Standard Deviation)**	**P-value**
Demographic Information	*Continuous Numeric Responses*		
Age	19.3 (1.0)	19.7 (1.0)	0.20
Years farming	8.2 (5.7)	8.4 (5.7)	0.89
Years applying	2.9 (2.0)	2.9 (2.7)	0.51
Pesticide Activities	*Likert-Scale Responses (1=Always, 5=Never)*		
Hired a contractor	4.0 (1.1)	3.6 (1.6)	0.53
Making the decision to apply pesticides	4.0 (1.3)	3.2 (1.6)	0.13
Applied pesticides in the last year	3.0 (1.0)	2.8 (1.0)	0.69
Safety Behaviors			
Wear gloves	1.7 (1.2)	1.8 (1.2)	0.85
Wear goggles	2.6 (1.6)	2.9 (1.6)	0.55
Wear a respirator	3.7 (1.4)	3.6 (1.7)	0.85
Wear a protective suit	3.8 (1.5)	3.6 (1.8)	0.90
Have a protective cab on the tractor	2.0 (1.5)	1.6 (1.3)	0.71
Wear long sleeves	2.6 (1.5)	2.5 (1.7)	0.70
Wear long pants	1.4 (0.8)	1.4 (1.0)	0.48
Read the pesticide label	2.1 (1.4)	2.1 (1.4)	>0.99
Discuss pesticide safety	2.5 (1.3)	2.4 (1.3)	0.84
Pesticide Resources			
Used internet to find pesticide information	3.3 (1.1)	2.8 (1.3)	0.40
Used internet for health and safety information	3.7 (1.4)	2.5 (1.5)	0.90

Discussion

A survey of 106 young agricultural workers was conducted to better understand their role in the pesticide application process, the concerns they have about pesticides, and what resources they use to find information about pesticides. Of the 106 participants, 36% (n=38) had any experience in pesticide application.

Pesticide Application

The first aim was to describe the role of young agricultural workers in agricultural pesticide applications and to identify the safety behaviors they utilize. While most participants who had ever worked with pesticides began working with them in the last two years, some participants had been working with pesticides for ten years, indicating that some were very young when this work started. Two participants who indicated working with pesticides for ten years reported that they started applying pesticides when they were ten and thirteen years old. Furthermore, around 65% of applicators reported applying pesticides two or more times in the past year. This finding may suggest that young agricultural workers may start applying pesticides early in their adolescence when they are going through a time of rapid development and put them at risk.

Most applicators reported applying pesticides to corn and soybeans, two of the most common crops in Iowa. These crops require multiple applications of pesticides throughout the growing season (Alavanja, 1999; USDA, 2019). Decisions to apply pesticides were not often made by the participants. Most participants indicated that the person who manages the farming operation or the person who has most experience on the farming operation (e.g., their parent or employer) makes the decision of what to apply and when to apply. While only 31.6% of participants who apply pesticides were certified pesticide applicators, the majority reported receiving some sort of training about pesticide safety practices. This training was typically provided by their employers or parents.

Pesticide safety practices and PPE use also differed among applicators. Safety practices frequently utilized by participants included glove use, wearing long sleeves, wearing long pants, using an enclosed cab, and reading the pesticide label. On the other hand, respirators and protective suits were seldom worn by participants. While it may appear that young agricultural workers choose not to use respirators or protective suits, the pesticides that were being applied and that the methods that were used to apply may not require the use of these PPE items (EPA, 2017). Reynolds et al. (2007) reported similar findings from surveys of farmers and non-farmers who had applied agrichemicals in rural Iowa. Among their population, PPE use was dependent on the chemical being applied. This study did not collect information about specific pesticides that were applied.

Concerns and Information Resources about Pesticides

The second aim was to identify pesticide related concerns and resources used by young agricultural workers to get information about pesticides. Young workers primarily used the internet to get information. This finding differed slightly from a previous survey which had the internet as the third most used resource for health and safety hazards, followed by community college and 4-H/Future Farmers of America (FFA) (Soupene, 2020). This finding is reflective of the trend of using the internet to find information by young people in the United States (Pew Research Center, 2019). While the internet was the most frequently reported resource used, how often it was used varied among participants with most only using it sometimes or half of the time. This finding demonstrates that internet users also utilize other sources for information on pesticides. University/college, government, and pesticide company sources were all almost equally utilized by most participants. Social media outlets, non-governmental organizations, and new media outlets were used much less. These findings are similar to previous research that found government and university sources more credible than non-governmental organizations (Felsot et al. (2002)). As more people use online sources to find health and safety information, there is a need to make sure these sources are accessible and contain comprehensive information needed to determine risk, safety strategies and emergency procedures.

Motives and barriers for using the internet were similar to findings from previous studies (Rutsaert et al. (2013). Speed and accessibility were the primary benefits identified for using the internet for information. Although misinformation was the main barrier for using the internet in previous research, we found that misinformation followed by lack of trustworthiness were the main barriers. Misinformation represented almost half of the recorded barriers to using the internet. While this is one of the first studies to examine misinformation in pesticides, other studies of the general population have described misinformation on the internet as a rising problem. For example, misinformation and quality of information related to COVID-19 has recently been examined (Cuan-Baltazar et al. (2020). Using the DISCERN principles, a measurement tool used to assess and score health information quality, 70% of websites were found to have a low score or were considered to contain low quality information (Cuan-Baltazar, 2020). Ensuring that online sources have trusted information and checking citations to see if they come from reliable sources is important to make sure that farmers have access to reliable and accurate information (Felsot, 2002).

Pesticide drift to crops was the most reported concern among the participants. This result could be due to the significant increase in pesticide drift cases in Iowa during recent years. According to a 2020 IDALS report on pesticide drift cases in Iowa, agriculture-related pesticide misuse cases (i.e., drift cases) increased from 89 to 295 between 2012 and 2020, respectively (IDALS, 2021). The least frequently selected concern was pesticide exposure to pregnant women. The individuals who selected this concern were equally divided between males and females. It is not clear why this concern was lower than others but may be due to their age and possibly not having children. Only three participants responded that they were not concerned about pesticide-related issues, which suggests that young agricultural workers recognize the risk to pesticides and have concern about their impact on the environment and health.

Risk-Accepting v. Risk Averse Comparison

The third aim was to examine the association between risk-accepting attitudes and safety behaviors. Slightly fewer participants were in the risk-accepting group (44.7%) compared to the risk-averse group (55.3%). This finding differed from a previous study (DellaValle, 2012), where 20% of participants were risk-accepting and may suggest that young agricultural workers are more risk-accepting. There were no statistically significant differences between the groups on pesticide safety behaviors, demographic characteristics, or sources used to find information about pesticides. This lack of statistical significance is most likely due to the small sample size. However, a larger percentage of applicators in the risk-accepting group used the internet for pesticide and health and safety information than those in the risk-averse group, although this difference was not statistically significant. This finding differed from DellaValle et al. (2012) which found that having risk-averse attitudes was associated with increased use of PPE. Differences in findings may be due to sample size, given that their study had 25,166 participants (DellaValle, 2012). Future studies should use a larger sample size to determine how risk-accepting attitudes impact safety behaviors.

Limitations

Generalizability of the sample was a limitation. Survey recruitment targeted individuals who attended agricultural science programs at college institutions in Iowa. Therefore, these results may not be generalized to all young agricultural workers in the midwestern United States. Small sample size was a limitation of this study. Power was calculated using OpenEpi, an opensource software program sample size calculator for proportions (Dean, 2013). We expected that 20% of our population would be risk-accepting (DellaValle, 2012). Therefore, a sample size of 94 would allow us to detect the percent of risk-accepting participants in the population with a precision of 95% (alpha = 0.05). To increase power, we planned to enroll 125 individuals in the study. The calculation was written assuming most participants would have experience applying pesticides, given that individuals in pesticide-related courses were targeted. However, only 36% of the participants in our sample reported applying pesticides. Future studies should focus on young workers actively engaged in pesticide application. The study was conducted during the COVID-19 pandemic. This difficulty limited the ability to interact with contacts or study participants in person and may have impacted recruitment. Recruitment relied on faculty members at each institution to disseminate the fliers and emails to their students. Participants may also have had difficulties with recalling past events (e.g., years of farming experience). However, most questions were written to describe actions at their most recent farming operation to minimize this issue. Despite these limitations, the study provides a basis for future studies that can employ similar measures to characterize pesticide exposure among young agricultural workers.

Conclusions

The goal of this study was to understand how young workers use pesticides and the safety measures they take to protect themselves. Young agricultural workers are involved in pesticide application at young ages. Furthermore, most participants were not involved in decisions about pesticide application, which may limit their control in implementing methods to reduce exposure, however most received training on pesticide safety. Although several safety practices such as wearing gloves and reading the pesticide label were frequently utilized. Although the use of a respirator or protective suit was seldom reported, this is likely due to the types of pesticides used and the methods of application which do not require these forms of PPE. This survey was also able to identify that participants were most concerned about environmental issues and long-term health outcomes associated with pesticide use and frequently used online resources to find information about pesticides. Developing trustworthy and credible online resources may be a way to promote pesticide safety behaviors among young agricultural workers.

CHAPTER III: FUTURE RESEARCH AND RELEVANCE

Relevance to Public Health

This study was developed to learn more about how young agricultural workers may be at-risk for pesticide exposure. A self-administered questionnaire was used to collect information on what safety measures (e.g., glove use, reading the pesticide label) young agricultural workers use when applying pesticides, whether they received training on pesticide safety, whether they are involved in decisions to apply pesticides, what concerns they have about pesticides, what resources they use to find information about pesticides, and how risk-attitudes towards safety may be associated with safety behaviors.

Most participants did not have any experience in pesticide application. While those that had applied pesticides reported they had only applied during the past three years, two participants reported applying pesticides for ten years, suggesting that they began applying when they were ten and thirteen years old. This finding suggests that some individuals begin applying pesticides early in adolescence and may be exposed during a period of rapid development, increasing their risk for adverse health outcomes (Rohlman, 2016). Additionally, most applicators were applying pesticides to either corn or soybeans, which typically require repeated applications of pesticides (Alavanja, 1999; USDA, 2019), and had sprayed more than twice in the past year. These findings suggest young workers may be at risk for repeated exposures to pesticides at an early age.

This study focused primarily on safety behaviors that could be implemented by young workers to prevent exposure. The majority of participants, when applying pesticides, always wore gloves, goggles, long sleeves, long pants, have an enclosed cab on the tractor, and read the pesticide label. On the other hand, most participants *never* wear a respirator or protective suit when applying pesticides. This finding is important to understand what young agricultural workers do to protect themselves from pesticide exposure. There could be several reasons for not wearing the respirator and protective suit such as what PPE is required on the pesticide label or the method of application (e.g., a protective suit would not be required when applying in an enclosed tractor cab).

Two questions were used to understand the decision-making process for applying pesticides (e.g., *who is responsible for making the decision to apply* and *describe how the decision is made to apply pesticides*). Most applicators stated that their parent or employer makes the decision to apply pesticides. This result was also confirmed by responses from all applicators when they described the process of when to apply pesticides, most indicated that someone (e.g., parent or employer) tells them when to apply. These findings demonstrate that the owner, a more senior employee, or a family member makes the decisions about pesticide application. It also shows that most young agricultural workers do not have decision making authority on the farming operation regarding pesticide application and, as a result, may not have control over training, availability of safety equipment, or policies to reduce exposure. Understanding who makes decisions on the farm is critical to understanding how safety and training measures are implemented and who has more influence in changing practices.

Most applicators had received training on pesticides at least once and they were trained by either their parent (35.6%) and/or employer (35.6%). This finding aligns with who is responsible for making the decision to apply pesticides. While 29.0% of participants reported always receiving training on pesticide safety, 31.6% of participants only received training sometimes before applying pesticides. These responses indicate that farming operations may differ in how often they cover training on pesticide use. It was hypothesized that participants who reported that they *always* received pesticide training worked for an employer where they may be required to provide pesticide training under the worker protection standard (WPS) (EPA, 2021b). However, about half the participants who listed *always* also reported that their parent was providing the training. These findings demonstrate that training is occurring both in the work environment and on the family farm. The lack of training indicates that this is an opportunity to promote safe pesticide behaviors (NIOSH, 2015).

When asked to describe pesticide-related concerns, most participants listed environmental concerns, specifically pesticide drift to crops (65.1%) and water contamination (62.3%). These concerns align with current news stories and the literature. For example, pesticide misuse complaints in Iowa have increased from 89 to 295 between 2012 and 2020 (IDALS, 2021). This increase is attributed to pesticide drift from herbicidal dicamba (IDALS, 2021). Water contamination has also been a recent concern in Iowa and the midwestern United States. There have also been several cases addressing contamination of waterways from corn seed treatment wastes in Mead, Nebraska (Dunker, 2021) and an Iowa lawsuit between a Des Moines drinking water provider and ten farm drainage districts over excess nitrate in drinking water (Buettner, 2017). This result may indicate that young agricultural workers are aware of current issues. Understanding what young agricultural workers are concerned about gives insight to public health professionals about what resonates with young workers and what may influence behavior change.

The internet was reported to be the primary resource for information about pesticides. While over 75% of participants reported using the internet, when asked how often they used the internet for pesticide information, most reported using it “half of the time” or “sometimes”. Participants would visit the online websites from a university or college, government sites (e.g., EPA), and pesticide company websites. University or collegiate websites and government websites have been identified as more credible sources of pesticide information because they typically provide citations and include information that allows an individual to assess risk (Felsot et al. 2002). In addition to online resources, other resources included colleges, pesticide dealers and senior family members. This finding demonstrates the need for a diverse distribution of pesticide safety information through multiple resources. This result is also useful for knowing what resources young agricultural workers use and where information about pesticide safety and health could be distributed.

When developing online resources, one needs to consider motives and barriers for using the internet (Rutsaert, 2013). Speed and accessibility are important, and with the increase in smartphone usage, the internet can be accessed immediately, and information can be found quickly (Gualtieri, 2012). Misinformation or lack of trustworthiness were the main barriers identified for online resources. This finding is not new; misinformation has also been described as a barrier for other public health issues, including the COVID-19 pandemic and the promotion of vaccinations (Cuan-Baltazar, 2020; Hoffman, 2019). Two ways to address misinformation include using social media sites to promote correct information (Hoffman et al., 2019) and to educate online users on ways to verify information (Cuan-Baltazar et al., 2020). Hoffman et al., (2019) suggests that social media outlets enable anti-vaccination organizations to use their sites, and the best way to oppose this issue, is to have social media networks provide targeted messages about the benefits of vaccinations to these groups (Hoffman, 2019). Cuan-Baltazar et al., (2020) recommends a similar strategy for challenging COVID-19 misinformation but also suggests that individuals should be taught how to verify information presented on online sites (Cuan-Baltazar, 2020). These strategies should be considered when finding ways to address misinformation about pesticide safety. Pesticide safety and health information should not be considered differently than other public health information and these findings have implications for public health professionals to consider misinformation as a problem when distributing pesticide information.

Finally, this study attempted to explore the association between risk-accepting attitudes and their association with safety behaviors. In order to perform this task, participants were grouped into risk-averse and risk-accepting categories. More participants were risk-accepting in comparison to a previous study which involved individuals of all ages (DellaValle, 2012). This result may suggest that young agricultural workers are more risk-accepting. A previous study indicated young agricultural workers are more risk-accepting or risk-taking due to social norms and risks associated with working in agriculture (Pickett, 2018). These findings should be considered when working with young workers in agriculture. Although no associations were found between the risk-accepting attitudes and safety behaviors, this is most likely due to the small number of applicators in the study. Previous studies that had used this assessment tool before had much larger sample sizes (Alavanja, 2001; DellaValle, 2012).

This study was one of the first to provide information about the roles of young agricultural workers during pesticide applications. While most participants did not have experience in applying pesticides, those who did may be at risk for repeated exposures. Most farms in Iowa are family-owned farms and produce corn and soybeans. Pesticides are applied multiple times throughout the application season using large spray equipment (e.g., self-propelled sprayer or tractor hitched sprayer). The findings also show that most of the decisions on when and how to apply were made by either the employer or a more senior family member, who were also responsible for providing the training. Although some safety precautions were regularly implemented, others were seldom used. Training, even though required to occur annually through the Worker Protection Standard, may be delivered inconsistently. These findings may be related to the types of crops and farms in Iowa. Finally, the internet is a useful tool for finding information about pesticides among most young agricultural workers. The internet, along with using other resources, can provide a platform to distribute reliable information about pesticides and other occupational hazards.

Future Studies

This study describes the role of young agricultural workers and pesticide application. Future studies should include questions about methods used for applying pesticides (e.g., self-propelled sprayer, aerial application) and additional measures of controls to reduce pesticide exposure including washing clothes after applying, hygiene practices, and the use of pesticide drift reduction technology. The only engineering control included in the current questionnaire was the use of an enclosed tractor cab. Other engineering controls should be included in the list of safety behaviors in future studies. We also did not ask about specific workplace policies or procedures to reduce exposure that may be implemented on the farm. More information about mixing pesticides, loading tanks, application, and maintaining equipment may also help to identify potential areas of exposure. Furthermore, more information should be collected to understand why certain measures of control are not used as often as others (e.g., respirators, protective suits). This study would provide a deeper understanding of pesticide exposure and guide future interventions.

There is also a need to gather additional information about the type of farming operation, the types of pesticides that are applied, and whether young agricultural workers are working on a family farm or as an employee. Family farms are exempt from OSHA inspections (OSHA, 2020) and are not required to provide annual pesticide safety training as described in the WPS (EPA, 2021b). This information may explain why some participants received training more often than others. While this study determined how many applicators received training and how often they received it, it did not ask questions about what topics the training covered.

Pesticide concerns should also be considered in future studies. Pesticide drift and water contamination were the most reported concerns among young agricultural workers. While cases of pesticide misuse are increasing (IDALS, 2021), this finding may be indicative of other issues including loss of crop yield or closing of farming operations (Ricco, 2018). Additional inquiries should ask follow-up questions about why they chose these as their main concern. Long-term health outcomes were also identified by about 43% of participants. This result shows some concern of the risks pesticides have to human health and provides an opportunity to raise awareness about these potential health effects that develop over time.

As a widely used resource, the internet provides information about safety behaviors and health effects. It is important to develop online sources that are trustworthy. However, little is known about the use of social media to promote health and safety behaviors. Although our study participants did not report using social media very often, information coming from trusted online sources (e.g., colleges or universities, government sites) is a potential opportunity to promote safe pesticide handling.

Questions about getting information about pesticides and health and safety information were asked from a broad standpoint (e.g., how often do you get information about pesticides on the internet). Information about where individuals go for specific types of information on pesticides (e.g., pesticide drift, application methods, symptoms of exposure) could expand our understanding of the utility of these online resources. Previous studies looked at performing this task (Felsot, 2002), but as new online platforms are developed (e.g., social media platforms, news media), there is a need to understand how these are used, specifically focusing on credibility since misinformation was listed as the primary barrier for using online sources. Perhaps, the study conducted by Felsot in 2002 should be conducted again as the internet use has increased since that time-period (Felsot, 2002; Pew Research Center, 2019).

While there was no statistical significance when comparing risk-accepting and risk-averse groups among variables, this result is most likely due to the small sample size. DellaValle et al. (2012) found an association between risk-accepting attitudes and not using PPE but included over 25,000 participants (DellaValle, 2012). This finding indicates that future studies with large sample sizes should consider utilizing this framework comparable to a previous study. Future studies should continue to examine the association between risk-accepting attitudes and safety behaviors used in pesticide application.

Conclusions

This study examined pesticide safety behaviors and resources utilized by young agricultural workers in the midwestern United States and provides a foundation for future studies. While most of our population had never applied pesticides, demographic information acquired from this survey provided insight into this population. Additionally, information obtained from study participants who have pesticide application experience is useful in understanding pesticide safety and training practices utilized on farming operations. This study is one of the first to document pesticide-related concerns among young agricultural workers and enhance our understanding of how the internet is utilized to find pesticide information. As online sources become more developed, all types of professionals will need to learn and adapt ways of providing pesticide safety information and how to understand and overcome barriers such as misinformation. In conclusion, this study offers the first insights into how young agricultural workers are involved in the pesticide application process. This study is one of few to focus specifically on young agricultural workers in the midwestern United States and their role in the pesticide application process. Information from this study provides information that can be used to influence educational and intervention practices.

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APPENDIX A: SURVEY FLYER

Survey Link:
https://tinyurl.com/y7yuc5t4

QR Code:

Pesticides are widely used in agriculture. Help us learn more about pesticide safety!

If you are between the ages of 18 and 29 and have farming experience in the midwestern United States, **we invite you to participate in an online survey from the University of Iowa about pesticide safety.**

You will earn a $10 check for completing our 15-minute survey.

Please scan the QR code or copy the survey link into your web browser. **For more information, please contact** victor-soupene@uiowa.edu

APPENDIX B: EMAIL CORRESPONDENCE

Email Title: Share your experiences and thoughts about pesticides.

THE UNIVERSITY OF IOWA
College of Public Health

To Whom I am addressing:

You are invited to participate in a research survey titled "Pesticide Safety Behaviors and Resources Utilized among Midwest College Students." This survey includes items about your background, your attitudes about pesticide risks, and resources you use to get information. **Upon completion of the survey, you will receive a $10 check for participating.**

In this study, you will be asked to complete an electronic survey. Your participation in this study is voluntary and you are free to withdraw your participation from this study at any time. The survey should only take 10 minutes to complete. **To qualify for this survey, you must between the age of 18-29 years AND have some farming experience in the midwestern United States.**

This survey has been approved by the Institutional Review Board at the University of Iowa. There are no risks associated with participating in this survey. The survey will collect your name and address following completion of the survey to mail your $10 checks, but all responses will be recorded anonymously beyond this point.

If you have any questions regarding the survey or this research project in general, please contact Victor Soupene at victor-soupene@uiowa.edu or (319) 821-0884. If you have any questions concerning your rights as a research participant, please contact the Human Subjects Office at the University of Iowa at irb@uiowa.edu or (319) 335-6564.

Please click on the survey link below to participate in the study.

https://uiowa.qualtrics.com/jfe/form/SV_7VTdn4DrQdYC8qp

Thank you for your consideration in participating.

Best Regards,

Victor Soupene, MS Candidate, University of Iowa

APPENDIX C: CONSENT LETTER

Introduction

You are invited to complete a short survey. The purpose of this research project is to examine pesticide safety behaviors and the sources of information used to get information about pesticides among young agricultural professionals in the Midwestern United States. This survey is sponsored by the University of Iowa College of Public Health.

Your participation is voluntary, and you can stop participation at any time.

A record of your participation in this research will be maintained but will be kept confidential through a password protected computer only available to the research team.

The online survey should take approximately 15 minutes to complete. After completing the survey, you will receive $10 for your participation.

If you have questions about the study, please call or email Victor Soupene at (319) 821-0884 or victor-soupene@uiowa.edu. Thank you for participating.

Instructions

This survey includes items about your background, your attitudes about pesticide risks, and resources you use to get information. Be sure to hit submit after completing the survey. Clicking Yes and the next button indicates you agree to be in the research study.

1. Do you agree to take this survey?

   ○ Yes

   ○ No

APPENDIX D: MAIN SURVEY

1. What is your age? (in years) ______
2. How many years have you been working in farming in the midwestern United States? (Note: if you have not worked in farming in the midwestern United States enter 0) _____
3. Which of the following colleges/universities do you attend?
   ○ Community College 1
   ○ Community College 2
   ○ University 1
   ○ Other (please specify): ______
   ○ Prefer Not to Answer
4. How do you identify your gender?
   ○ Male
   ○ Female
   ○ Transgender Female
   ○ Transgender Male
   ○ Genderqueer
   ○ Gender Non-Conforming
   ○ Non-Binary
   ○ Not Listed: ________
   ○ Prefer Not to Answer
5. In what state were you born?
   ○ Iowa
   ○ Illinois
   ○ Minnesota
   ○ Wisconsin
   ○ Nebraska
   ○ Missouri
   ○ Other (please specify): _______
   ○ I am not from the United States.
6. How many years have you been applying pesticides in an agricultural setting? (Note: if you do not or have not applied pesticides enter 0) ______
7. Which crops have you applied pesticides to? (Check all that apply)
   □ Corn
   □ Soybeans
   □ Cotton
   □ Fruit
   □ Vegetables
   □ Other (please specify):______
8. Are you a certified pesticide applicator?
   ○ Yes, Commercial
   ○ Yes, Private
   ○ No
   ○ Unsure

9. During the past year, how often did you apply pesticides?
   ○ Never
   ○ Once
   ○ Twice
   ○ Three times or more
10. Have you ever received training on pesticide safety?
   ○ Yes
   ○ No
   ○ Unsure
11. At your most recent farming operation, how often do/did you receive training before applying pesticides?
   ○ Always
   ○ Most of the time
   ○ About half the time
   ○ Sometimes
   ○ Never
   ○ Unsure
   ○ Prefer not to say
12. At your most recent farming operation, who provided the pesticide training sessions? (Check all that apply)
   □ Employer
   □ Parent (if work on a family farm)
   □ Sibling (if work on a family farm)
   □ Other Family Members (if work on a family farm)
   □ Pesticide Contractor
   □ Coworker
   □ Other (please specify): _____
13. When you handle or apply pesticides at your most recent farming operation, how often do/did you use the following? [Matrix Table Format: Gloves, Goggles, Respirator, Protective Suit, Enclosed Cab on Tractor, Long sleeves, Long pants, Other (please specify): _______
   ○ Always
   ○ Most of the time
   ○ About half the time
   ○ Sometimes
   ○ Never
14. At your most recent farming operation, how often do/did you read the pesticide label before handling or applying pesticides?
   ○ Always
   ○ Most of the time
   ○ About half the time
   ○ Sometimes
   ○ Never
   ○ Only when it is a new product I have not used before.
   ○ Unsure
   ○ Prefer not to say

15. At your most recent farming operation, how often are you involved in making the decision to apply pesticides?
    ○ Always
    ○ Most of the time
    ○ About half the time
    ○ Sometimes
    ○ Never
    ○ Unsure
    ○ Prefer not to say
16. Please describe in the text box below how a decision is made to apply pesticides at your most recent farming operation. _____
17. At your most recent farming operation, who is responsible for making decisions about pesticide application? (Choose ALL that apply)
    □ Employer
    □ Parent (if work on family farm)
    □ Sibling (if work on family farm)
    □ Other Family Members (if work on family farm)
    □ Pesticide Contractor
    □ Coworker
    □ Other (please specify):______
    □ Unsure
    □ Prefer not to answer
18. At your most recent farming operation, how often do/did you talk about safety before handling or applying pesticides?
    ○ Always
    ○ Most of the time
    ○ About half the time
    ○ Sometimes
    ○ Never
    ○ Unsure
    ○ Prefer not to say
19. Have you ever worked for an organic farming operation?
    ○ Yes
    ○ No
    ○ Unsure
20. At your most recent farming operation, how often do/did you or your operation hire a contractor to apply pesticides?
    ○ Always
    ○ Most of the time
    ○ About half the time
    ○ Sometimes
    ○ Never
    ○ Unsure
    ○ Prefer not to say

21. Which of the following pesticide-related issues are you concerned about? (Select all that apply)
    □ Pesticide drift to crops
    □ Pesticide drift to homes
    □ Long-term health outcomes (e.g., cancer, diabetes)
    □ Short-term health outcomes (e.g., acute pesticide poisoning, illness)
    □ Exposure to young children
    □ Water contamination
    □ Food contamination (e.g., pesticide residues on fruit)
    □ Environmental concerns (e.g., plant and wildlife contamination)
    □ Pesticide resistance
    □ Exposure to pregnant women
    □ Effectiveness in eliminating pests
    □ Other (please specify):______
    □ I am not concerned about pesticide-related issues
22. Which of the following sources do you use to find information on pesticides? (Select all that apply)
    □ Internet
    □ Pesticide Dealer/Elevator
    □ University/College (e.g., Iowa State)
    □ 4-H/FFA
    □ Agricultural Extension Office
    □ Friend or Family Member
    □ Other (please specify):______
    □ I have not looked for information on pesticides
23. How often do you get information about pesticides on the internet?
    ○ Always
    ○ Most of the time
    ○ About half the time
    ○ Sometimes
    ○ Never
    ○ Unsure
    ○ Prefer not to say
24. Which of the following internet resources do you use when finding information on pesticides?
    □ Government (e.g., EPA)
    □ University/College (e.g., Iowa State)
    □ Non-Governmental Organization (NGO's) (e.g., Practical Farmers of Iowa)
    □ Social Media (e.g., Facebook)
    □ Pesticide Company (e.g., Bayer CropScience)
    □ New Media Outlets (e.g., CNN)
    □ Other (please specify):______

25. How often do you get information about health and safety issues on the internet?
   ○ Always
   ○ Most of the time
   ○ About half the time
   ○ Sometimes
   ○ Rarely
   ○ Unsure
   ○ Prefer not to say
26. Which of the following are reasons for using the internet for information? (Check all that apply)
   □ Accessibility
   □ Speed
   □ Social Interaction
   □ Technological Possibilities (e.g., photos, videos)
   □ Other (please specify):______
   □ I do not use the internet.
27. Which of the following are barriers for using the internet for information? (Check all that apply)
   □ Accessibility
   □ Competition of Traditional Media
   □ Misinformation
   □ Speed
   □ Time-consuming
   □ Other (please specify):______
   □ I do not use the internet.

To what degree do you agree or disagree with the following statements?

28. Farming is more dangerous than jobs in industry or manufacturing.
   ○ Strongly agree
   ○ Somewhat agree
   ○ Somewhat disagree
   ○ Strongly disagree
29. Accidents are just one of the occupational hazards of pesticide application that must be accepted if you are going to be in the business.
   ○ Strongly agree
   ○ Somewhat agree
   ○ Somewhat disagree
   ○ Strongly disagree
30. During a normal week, it is common for me, while doing pesticide-related work, to experience a number of "close calls" that might have resulted in injury/property loss.
   ○ Strongly agree
   ○ Somewhat agree
   ○ Somewhat disagree
   ○ Strongly disagree

31. To make a profit, most farmers take risks that might endanger their health.
    - ○ Strongly agree
    - ○ Somewhat agree
    - ○ Somewhat disagree
    - ○ Strongly disagree

Please click submit to complete this survey. If you have questions about the study, please call or email Victor Soupene at (319) 821-0884 or victor-soupene@uiowa.edu. Thank you for participating.

After you click submit you will be asked to provide your contact information for us to mail your $10 check.

APPENDIX E: FOLLOW-UP SURVEY

Instructions:

Thank you for participating in our short survey. We sincerely appreciate your feedback. If you would like to be compensated for taking this survey, please answer the following questions and click submit. You will receive your compensatory check through the mail. You must answer all of the questions below to receive compensation. If you do not want to be compensated, you may close out of this survey. If you have questions about the study, please call or email Victor Soupene at (319) 821-0884 or victor-soupene@uiowa.edu. Thank you again for participating.

1. What is your name?
    a. First Name ______
    b. Last Name ______
2. What is your home address?
    a. Street Number/Name ______
    b. City, State, Zip Code ______

APPENDIX F: SAS CODE FOR DATA ANALYSIS

```
***Thesis Data Among All Participants***;
libname mydata 'h:/mydata';
Proc Print data=mydata.AllPar;
Run;

**Cronbach's Alpha for Likert-Scale;

proc corr data=mydata.AllPar alpha nomiss;
var FarmDanger Accidents CloseCalls Risks;
Run;

Proc univariate data=mydata.PestPar;
var FarmDanger Accidents CloseCalls Risks;
Run;

**PestPar**;
libname mydata 'h:/mydata';
Proc Print data=mydata.PestPar;
Run;


**Divide Groups into Risk-Averse and Risk-Accepting**;

Data mydata.PestPar1;
set mydata.PestPar;
if farmdanger lt 3 then farmdanger_r = 1;
else farmdanger_r =0;
if accidents lt 3 then accidents_r = 1;
else accidents_r =0;
if CloseCalls lt 3 then CloseCalls_r = 1;
else CloseCalls_r =0;
if Risks lt 3 then Risks_r = 1;
else Risks_r = 0;
risk_accept = farmdanger_r + accidents_r + CloseCalls_r + Risks_r;
if risk_accept >= 3 then risk_class = 1;
else risk_class =0;
run;
proc print data=mydata.PestPar1;
Run;

**Pesticides**;
proc means data=mydata.PestPar1 mean std;
var Pesticides__Internet_;
class risk_class;
run;
proc npar1way data=mydata.PestPar1 wilcoxon;
  class risk_class;
  var Pesticides__Internet_;
run;
```

```
**HandS**;
proc means data=mydata.PestPar1 mean std;
var HandS__Internet_;
class risk_class;
run;
proc npar1way data=mydata.PestPar1 wilcoxon;
  class risk_class;
  var HandS__Internet_;
run;

**Contractor**;
proc means data=mydata.PestPar1 mean std;
var Contractor;
class risk_class;
run;
proc npar1way data=mydata.PestPar1 wilcoxon;
class risk_class;
var Contractor;
run;

**Age**;
proc means data=mydata.PestPar1 mean std;
var Age;
class risk_class;
run;
proc npar1way data=mydata.PestPar1 wilcoxon;
class risk_class;
var Age;
run;

**FarmYears**;
proc means data=mydata.PestPar1 mean std;
var FarmYears;
class risk_class;
run;
proc npar1way data=mydata.PestPar1 wilcoxon;
class risk_class;
var FarmYears;
run;

**PesticideYears**;
proc means data=mydata.PestPar1 mean std;
var PesticideYears;
class risk_class;
run;
proc npar1way data=mydata.PestPar1 wilcoxon;
class risk_class;
var PesticideYears;
run;
```

```
**Apply**;
proc means data=mydata.PestPar1 mean std;
var Apply;
class risk_class;
run;
proc npar1way data=mydata.PestPar1 wilcoxon;
class risk_class;
var Apply;
run;


**Gloves**;
proc means data=mydata.PestPar1 mean std;
var Gloves;
class risk_class;
run;
proc npar1way data=mydata.PestPar1 wilcoxon;
class risk_class;
var Gloves;
run;

**Goggles**;
proc means data=mydata.PestPar1 mean std;
var Goggles;
class risk_class;
run;
proc npar1way data=mydata.PestPar1 wilcoxon;
class risk_class;
var Goggles;
run;

**Resp**;
proc means data=mydata.PestPar1 mean std;
var Resp;
class risk_class;
run;
proc npar1way data=mydata.PestPar1 wilcoxon;
class risk_class;
var Resp;
run;

**Suit**;
proc means data=mydata.PestPar1 mean std;
var Suit;
class risk_class;
run;
proc npar1way data=mydata.PestPar1 wilcoxon;
class risk_class;
var Suit;
run;
```

```
**Cab**;
proc means data=mydata.PestPar1 mean std;
var Cab;
class risk_class;
run;
proc npar1way data=mydata.PestPar1 wilcoxon;
class risk_class;
var Cab;
run;

**LongS**;
proc means data=mydata.PestPar1 mean std;
var LongS;
class risk_class;
run;
proc npar1way data=mydata.PestPar1 wilcoxon;
class risk_class;
var LongS;
run;

**LongP**;
proc means data=mydata.PestPar1 mean std;
var LongP;
class risk_class;
run;
proc npar1way data=mydata.PestPar1 wilcoxon;
class risk_class;
var LongP;
run;

**Label**;
proc means data=mydata.PestPar1 mean std;
var Label;
class risk_class;
run;
proc npar1way data=mydata.PestPar1 wilcoxon;
class risk_class;
var Label;
run;

**Decision**;
proc means data=mydata.PestPar1 mean std;
var Decision;
class risk_class;
run;
proc npar1way data=mydata.PestPar1 wilcoxon;
class risk_class;
var Decision;
run;
```

```
**Talk**;
proc means data=mydata.PestPar1 mean std;
var Talk;
class risk_class;
run;
proc npar1way data=mydata.PestPar1 wilcoxon;
class risk_class;
var Talk;
run;

**Chi-Square Test for Yes/No**;
**Gender**;
Data mydata.PestParM;
set mydata.PestPar1;
if Gender = 8 then Gender = .;
run;
proc freq data=mydata.PestParM;
  tables risk_class*Gender / chisq;
run;
**Organic**;
Data mydata.PestParO;
set mydata.PestPar1;
if organic=3 then organic=.;
run;
proc freq data=mydata.PestParO;
  tables risk_class*organic / chisq;
run;

**Pestsafe**;
proc freq data=mydata.PestPar1;
  tables risk_class*Pestsafe / chisq;
run;

**License**;
Data mydata.PestParL;
set mydata.PestPar1;
if License = 3 then License=.;
run;
proc freq data=mydata.PestParL;
   tables risk_class*License / chisq;
run;
```