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Migrant farmworkers' perceptions of pesticide risk exposure in Adams County, Pennsylvania: A cultural risk assessment

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Abstract

Agricultural exceptionalism, a system in which regular labor laws and standards do not apply to farm labor, makes migrant farmworkers particularly vulnerable populations—economically, socially, and in terms of environmental health. To address inequities inherent in migrant farmworker marginalization, studies advocate for actively engaging the migrant farmworker population in the conversation surrounding these issues. We conducted 40 semi-structured interviews with migrant farmworkers in Adams County, Pennsylvania, to understand pesticide risk exposure perceptions and practices. We employed the Health Belief Model as our cultural risk assessment frame, using it in combination with technical risk assessment, which uses government calculations (from the Environmental Protection Agency) to quantify pesticide risk exposure. We used mixed methods analyses (quantitative and qualitative) to compare and understand farmworker demographics, perceived risk, perceived control, and risk behavior. Results show that demographics—e.g., age, education, visa status—are important factors in risk perception. They also confirm observations present in many earlier studies. While trainings and educational materials are valuable to help build awareness of risk, a systemic lack of control over their circumstances make it hard for migrant farmworkers to engage in safe behavior. Results also highlight the limitations of technical risk assessment. Such calculations, however, rarely account for risk perceptions and experiences of farmworkers themselves. Acknowledging the voices of migrant farmworkers is an essential first step in rebalancing inequities of power in our food

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systems, and cultural risk assessment can help frame recommendations that target different stakeholders across the pesticide regulatory spectrum to ensure migrant farmworker needs and safety.

Keywords
Migrant Farmworkers; Pesticides; Cultural and Technical Risk Assessments; Health Belief Model; Pennsylvania

Introduction

In 1962, Rachel Carson's *Silent Spring* and Murray Bookchin's *Our Synthetic Environment* exposed scientific research that alerted the American public to the ecological and health impacts of pesticides. At the same time, Cesar Chavez and Dolores Huerta's establishment of the United Farm Workers Union (UFW) alerted the nation to migrant farmworker conditions. While their work has influenced policies such as the establishment of the Environmental Protection Agency (1970), the Occupational Health and Safety Act (1970), and the Worker Protection Standard (originally enacted in 1992 with several revisions that have modified the act, including the most recent revision in 2017), various studies note that the general characteristic that defines the farming sector is one of *agricultural exceptionalism*. Legacies of systemic racism, indentured servitude, and entrepreneurial exploitations persist in public policy and on-the-ground practice. Such policies and practices inhibit farmworkers' rights to regular standards and laws of labor protection, including those of occupational health (Rodman, Barry, Clayton, Frattaroli, Neff, & Rutkow, 2016; Weiler, Levkoe, & Young, 2016). For example, state-level policies often undermine federal-level labor protections, specifically with regards to minimum wage, overtime protections, and meal and rest periods (Rodman et al., 2016). Farm work is notoriously demanding, and through much of the nation's history, farmworkers have consisted of groups disenfranchised along lines of race, ethnicity, and citizenship status (Gray, 2013; Holmes, 2013; Southern Poverty Law Center, 2013). The National Center for Farmworker Health estimates that there may be more than three million migrant farmworkers in the U.S. (2012), most of whom come from Mexico and Central America (Southern Poverty Law Center, 2013). Some come on temporary H-2A visas as part of the H-2 guest worker program,[1] but the bureaucracy associated with this program makes it uninviting and difficult. Thus, many migrant farmworkers remain undocumented in the federal system (Gray, 2013; Holmes, 2013; Rodman et al., 2016).

Working long hours in fields, orchards, barns, and slaughterhouses, migrant farmworkers are at the frontlines of pesticide risk exposure. At a fundamental level, their safety is dependent on the defined limits on pesticide use instituted by federal and state governments. Specifically, the U.S. Environmental Protection Agency (EPA) employs numerical equations for oral, dermal, and inhalation exposure to calculate the risk associated with pesticide exposure and to designate proper application use and restrictions. Such calculations compose a *technical risk assessment*. However, scholars have argued that technical risk assessments fail to comprehensively assess risk, as risk is subjective and socially constructed. When communities do not have a say in decision-making, both the risk assessments and the communities at risk can overestimate or underestimate the threat (Bickerstaff, 2004; Cox, 2012; Finucane & Holup, 2005; National Research Council, 1996; Renn, 1992). In contrast to technical risk assessment, *cultural risk assessment* considers how and why risk is understood and perceived differently by certain populations and individuals. For example, Bickerstaff (2004) found that political and economic marginalization of a group tended to escalate personal concerns about environmental risks (specifically air pollution in her case study) as well as feelings of helplessness. This was caused by, and contributes to, a lack of trust that government and regulatory agencies will act justly. In essence, the voices of those at risk are

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[1] H-2A is a federal work-visa program that partners U.S. employers with foreign workers to fill temporary or seasonal agricultural jobs. It is explicitly aimed to satisfy needs of employers who are unable to find willing, qualified, and/or available U.S. workers for the temporary work, and is predicated on workers returning to their home countries when the job needs are satisfied.

important. As Patricia Allen writes in the introduction to this journal's special issue (2016), *Labor in the food system, from farm to table*, "where workers are not consulted, knowledge and policy cannot take into account the circumstances, motivations, and aspirations of those at the point of production… This is dangerous for workers and consumers alike" (p. 2). By capturing the voices of those at risk, cultural risk assessment can help address important safety considerations to protect marginalized farmworkers.

The primary objective of this study is to better understand the factors that influence the perception of pesticide risk held by migrant farmworkers. The study draws on previous pesticide studies that engage cultural risk assessments and provides two new dimensions to such research. First, this study puts technical risk assessment methods in direct dialogue with cultural risk assessment. Embracing both aspects of risk is important to align the interests of different stakeholders (e.g., farm owners, the government, and farmworkers) in order to identify and enforce pesticide exposure risk mitigation strategies. Second, this study focuses on Adams County, Pennsylvania, an important agricultural region in which many farmers are dependent on migrant labor; nevertheless, it is a region that has not been well studied. Indeed, despite the approximately 45,000 to 50,000 migrant and seasonal farmworkers in Pennsylvania, there is only one study examining occupation health and migrant farmworker perceptions (Cason, Snyder, & Jensen, 2004). Our findings can illuminate and shape migrant farmworker safety concerns, risk communication, and pesticide exposure standards; thus, we also make recommendations for pesticide risk mitigation strategies.

Pesticide Exposure and Risk Assessment

Pesticide exposure studies identify a wide range of pesticide-related illnesses from which migrant farmworkers suffer due to chronic, low exposure to pesticides, primarily absorbed dermally and secondarily inhaled or ingested (Arcury & Quandt, 1998; Arcury, Quandt, Cravey, Elmore, & Russell, 2001; Ciesielski, Loomis, Mims, & Auer, 1994; Colt, Stallones, Cameron, Dosemeci, & Zahm, 2001; Sakala, 1987; Wilk, 1986). Symptoms and illnesses from pesticide exposure include headaches, nausea, dermatitis, respiratory failures, musculoskeletal problems, cognitive effects, and cancer. In some cases, death can be an outcome.

Assessing the health effects of chronic, low-level exposure to pesticides is inherently complicated. Health effects from pesticide exposure can be easily mistaken for other occupational health symptoms that farmworkers may experience—for example, heat stress and reaction to plants (Arcury & Quandt, 1998). Furthermore, the transient nature of migrant farmworkers coupled with their often undocumented status makes longitudinal tracking of participants particularly difficult. For example, illnesses such as cancers can take years to appear following occupational pesticide exposure (Arcury & Quandt, 1998). Since direct measurement of pesticide exposure is time consuming and difficult, governmental and research organizations use risk assessment models instead.

Technical Risk Assessment of Pesticide Exposure

The U.S. Environmental Protection Agency (EPA) typically uses a technical risk assessment protocol to calculate the risk associated with pesticide exposure and to designate application use and restrictions. The agency employs the National Research Council's process for human health risk assessment: hazard identification, dose-response assessment, exposure assessment, and risk characterization (Pedersen, 1997). Furthermore, the EPA acknowledges three main routes that can lead to pesticide exposure: oral, inhalation, and dermal. The EPA has several calculations for determining exposure (Pederson, 1997; U.S. EPA, 1994, 2007; U.S. EPA, Office of Pesticide Programs, 2002; U.S. EPA, Office of Pesticide Programs, 2013; U.S. EPA, Office of Superfund Remediation and Technology Innovation, 2004). Models that best measure pesticide exposure for farmworkers consider factors such as contaminant residue, contact with the residue, frequency, time span, duration of exposure, and body weight to calculate an Average Daily Dose (ADD) for all three routes of exposure. The ADD can then be compared to the EPA's data on a particular pesticide's Oral

Reference Dose (RfD) or Inhalation Risk Concentration (RfC), an estimate of a daily exposure to the human population that is likely to be without an appreciable risk of deleterious effects during a lifetime. RfD and RfC are experimentally determined, often by using test animals. A Hazard Quotient (HQ) is calculated to determine risk by dividing the RfD (or RfC) by the ADD. If the HQ is greater than one, an adverse health effect is expected (U.S. EPA, 2005; U.S. EPA, Office of Superfund Remediation and Technology Innovation, 2004).

Dermal exposure risk, calculated specifically for farmworkers, is an estimate of the dermal exposure via a transfer coefficient, a known variable for most crops and activity combinations (e.g., hand harvesting of peaches). The dermal exposure uses the same units as ADD (mg/kg-day), so the same HQ equation applied to oral and inhalation exposure can be used to calculate the dermal exposure (U.S. EPA, Office of Pesticide Programs, 2013).

Overall, technical risk assessments provide generalizable calculations to inform worker safety legislation; however, they do have limitations. First, calculations do not consider the cumulative risk of oral, inhalation, and dermal exposure. That is, there are three separate HQs for each exposure type, but none that considers them together. Second, they do not consider the combination and/or interaction of different chemicals that one might be exposed to within the individual calculations of exposure. Third, they do not consider an individual's perceptions or experiences of risk, which, as a number of studies indicate, is essential to effectively addresses risk (Bickerstaff, 2004; Cox, 2012; Finucane & Holup, 2005; National Research Council, 1996; Renn, 1992). If people do not perceive themselves to be at risk, they might not take necessary mitigating action, thus endangering themselves and others. Conversely, if people perceive greater risk than what exists, this too can be problematic, as it results in unnecessary concern and resource misallocation. Thus, cultural risk assessment has been utilized in pesticide risk studies, as elaborated below, to resolve such limitations associated with technical risk calculations.

Cultural Risk Assessment of Pesticide Risk Using the Health Belief Model (HBM)

Cultural risk assessment examines how risk is understood and perceived by different populations and individuals (Bickerstaff, 2004). A common model for cultural risk assessment is the Health Belief Model (HBM), which seeks to assess how behavior is a function of a person's subjective appraisal of risk and recognizes that perceiving risk is the first step toward taking action for risk mitigation. The HBM posits that there are six variables that predict *risk behavior:* risk susceptibility, risk severity, benefits to action and barriers to action, self-efficacy, cues to action, and demographics (Hayden, 2013; Jones et al., 2015; Table 1).

Methodologically, studies informed by HBM use statistical analyses to understand the correlations between these variables. An extensive meta-analysis of HBM research conducted by Jones, Jensen, Scherr, Brown, Christ, and Weaver (2015) identified certain limitations of the HBM model. Most notably, the ordering of variables is currently undefined in the HBM. For example, it does not define whether relationships occur in parallel (are severity and susceptibility simultaneous?), in serial (does severity effect susceptibility?), or in tandem

Table 1. HBM Variables that Predict Risk Behavior [a]

HBM variables	Definition
Risk susceptibility	The belief one is at risk
Risk severity	By how great the risk is
Benefits/Barriers to risk behavior	If a behavior will mitigate risks
Self-efficacy (or barriers to self-efficacy)	The belief one can(not) take action to mitigate risk
Cues to action	Knowledge provided by educational material or personal experience
Demographics	Age, ethnicity, socioeconomic status, etc.

[a] Risk behavior is defined as the likelihood that a person will engage in a risky or risk-mitigation behavior.

(do severity and susceptibility occur together, even if they are ordered?).

These limitations notwithstanding, the HBM is still a useful conceptual starting point for understanding risk (Jones et al., 2015). The model has been applied frequently to understand pesticide risk behavior (Arcury, Quandt, & Russell, 2002; Khan, 2010; Quandt et al., 2001; Snipes et al., 2009). These studies often simplify the model to examine specific variable correlations of interest. For example, in their study focused on North Carolina farmworkers, Arcury et al. (2002) examined how susceptibility and severity contribute to understandings of perceived risk and how self-efficacy contributes to perceived control. They were also interested in how access to safety information correlated to perceived risk and control.

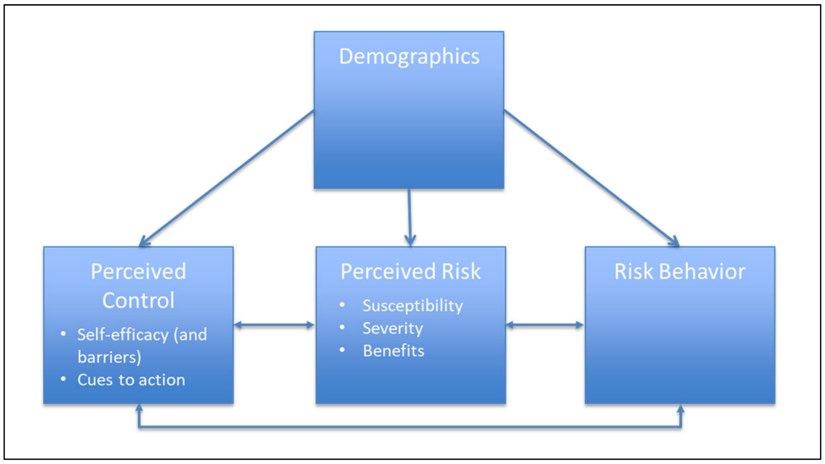
Many studies on pesticide risk use the HBM as a frame; others do not use this framework explicitly, but rather use pesticide risk components that overlap that of HBM. Whether qualitative or quantitative, these studies seek to understand participants' perceptions, including perceptions of risk control. For example, in their qualitative analysis of interviews with farmworkers in California's Salinas Valley, Cabrera and Leckie (2009) found that many farmworkers have higher levels of risk perception than the general public, but nonetheless engage in risky behaviors (e.g., wearing short sleeves or no shirt in the fields). Cabrera and Leckie suggest that such risky behavior may be because farmworkers do not believe they have control (i.e., self-efficacy) over reducing their exposure, even if they change their behavior. However, a qualitative analysis by Elmore and Arcury (2001) showed that farmworkers who have perceived control, such as the ability to wash their hands and shower immediately following work (again, a form of self-efficacy), do engage in mitigation behaviors. Using a multivariable ordinal logistic regression analysis, Levesque and Arif (2014) similarly suggest that perception of control can predict reduced pesticide exposure among seasonal and migrant farmworkers. Their findings are supported by studies such as Arcury et al. (2002), which cite the HBM as a frame. Arcury et al. (2002), Damalas and Hashemi (2010), and Snipes et al. (2009) also explore how demographic variables are correlated with risk behavior. Overall, the HBM, even when simplified to focus on a subset of variables, is a useful conceptual model for assessing pesticide risk.

Research Design

Research Question and Conceptual Model

As with previous studies, we wished to learn how perceived risk, perceived control, and demographics relate to pesticide risk behavior in order to facilitate the development of effective risk mitigation strategies. Thus, in this study we ask the following research question: *how do four crucial aspects of cultural risk assessment—perceived risk, perceived control, demographics, and risk behavior—correlate to each other?* In addressing this question, as with many previous studies (e.g., Arcury et al., 2002; Khan, 2010; Quandt, Arcury, & Pell, 2001; Snipes et al., 2009), we engage the HBM as a conceptual frame and simplify it to illuminate broad understandings of risk and control perceptions, demographics, and risk behavior (Figure 1).

Figure 1. Conceptual Model Based on Health Belief Model Variables Indicating the Relationships Explored in this Study
The demographic variables, which we understand as modifying factors for the three other categories, are listed in Table 2.



Our research was conducted with many of the principles of community-based research (CBR) in mind. We initiated the study based on the invitation of community partners who are well known and trusted within the migrant community, namely the Lincoln Intermediate Unit (LIU) Migrant Education Program in Pennsylvania (a program that assists farmworkers primarily through educational opportunities). Though the specific time constraints of the farmworkers meant we were unable to collaborate on survey design, our research was conducted with the explicit aim to share findings with our community partners and to respect and validate the knowledge of the farmworkers to help generate social change. These three principles of community collaboration—working on topics of concern initiated by the community, sharing knowledge with them, and validating stakeholder knowledge to instigate social change—are central to CBR (Gettysburg College, Center for Public Service, 2017).

Survey Design

To answer the research question, we designed a survey that maintains compatibility with previous pesticide risk studies that conducted statistical analyses centered around HBM variables. In designing our survey, we used Likert scale questions (similar to those use by Quandt et al., 2001, Arcury et al., 2002, and Cabrera and Leckie, 2009), and, because we were keen to understand the concerns of farmworkers in their own voices, we also included open-ended questions.

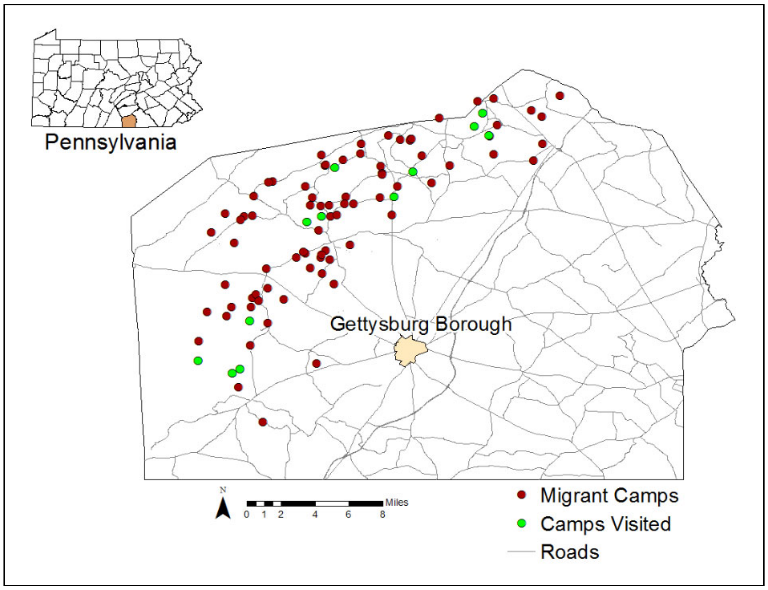
The survey was designed to be administered in 30 to 60 minutes and was tested in the field before it was deployed. This test resulted in a shortening of the original survey—for example, we removed a few perceived control questions we had originally taken from the Arcury et al. (2002) study in favor of keeping the open-ended questions. While our shortened survey instrument did not allow us to generate the perceived control indices that Arcury et al. (2002) developed, it was quicker and simpler to administer than the test survey. The resulting survey (Appendix A) included 12 perceived risk questions, 15 perceived control questions, 8 demographic questions, and 2 risk behavior questions. It also included 6 technical risk assessment questions, which we initially hoped to utilize to create estimates of actual exposure. The survey was available in both English and Spanish.

Our survey instrument is not exactly the same as those used in previous works, which could be construed as a limitation. However, given that many studies, such as Snipes et al. (2009), tailor their HBM frame to their specific research sites and concerns, we do not necessarily see this as a problem. Instead, as we discuss in the results, our survey still yielded many valuable insights that can be used in conjunction with previous studies. In addition, the qualitative information gained from the open-ended questions added important nuances to our statistical relationships.

Data Collection

LIU's Migrant Education Program helped facilitate contact with farmworkers at 13 housing sites in Adams County, Pennsylvania. We conducted 40 semistructured interviews with seasonal workers between September and October 2016 (Figure 2).

Figure 2. Map of Migrant Camps in Adams County, Pennsylvania



These months are prime apple harvesting season in the nation's sixth-largest apple producing county (U.S. Department of Agriculture, 2012). Interview responses and field notes were compiled in a Microsoft Excel spreadsheet. Additionally, though we did not ask about visa status in the questionnaire, we noted whether respondents voluntarily disclosed their visa status during the interview.

Data Analysis

Our analysis of survey responses employed both quantitative and qualitative methods. In terms of quantitative methods, descriptive statistics were calculated for the demographic measures. Cross-tabs were used to compare questionnaire responses between the categories shown in Figure 1 (e.g., demographics vs. perceived control, perceived risk vs. risk behavior, etc.). Fischer's Exact test was used to determine the significance of the relationships ($p<0.05$), while Cramér's V was used to determine the strength of the significant relationships. In addition, Cramér's V was used to identify strongly correlated responses within categories so that they would not be interpreted as separate phenomena. For example, in the case of demographics, age is correlated both with total years working in agriculture and years working in agriculture in the U.S.). We identified redundant relationships through intravariable cross-tab comparisons at $p<0.05$; we then presented the highly correlated variables together as single relationships in the results (Table 2). All quantitative analyses were conducted using SPSS software.

In terms of qualitative methods, we transcribed field notes, carefully noting comments the farmworkers added to their survey responses to showcase specific observations made by the farmworkers in their own words. Similar to grounded theory methodology, which looks for patterns and themes that emerge from within responses, we also examined our data to identify recurrent concerns within the comments and responses of the farmworkers (Bernard, 2011; Scott, 2009). However, as our sample size was small, we did not formally code the responses; instead, our analysis, which involved careful familiarity with notes and cross-checks within the data, sought to highlight additional insights and themes that might have been missed by the statistics.

Table 2. Cramér's V Correlation Tests Conducted to Determine if There is a Correlation Within Demographic, Perceived Risk, and Risk Behavior Variables for Similar Questions/Responses (*n*=40)
No similar perceived control questions were asked.

Variable 1	Variable 2	Cramér's V significance
	Demographic Variables	
Age	Before US Ag duration	0.283
Age	US Ag duration	0.000*
Age	Total Ag duration (<15/15+)	0.016*
Age	Total Ag duration (<25/25+)	0.002*
Before US Ag duration	US Ag duration	0.433
Before US Ag duration	Total Ag duration (<15/15+)	0.005*
Before US Ag duration	Total Ag duration (<25/25+)	0.000*
US Ag duration	Total Ag duration (<15/15+)	0.011*
US Ag duration	Total Ag duration (<25/25+)	0.001*
	Perceived Risk Variables	
Short exposure	Short impact	0.000*
Short exposure	Short impact fatal	0.309
Short exposure	Can name short illness	0.000*
Short impact	Short impact fatal	0.309
Short impact	Can name short illness	0.001*
Short impact fatal	Can name short illness	0.279
Long exposure	Long impact	0.000*
Long exposure	Long impact fatal	0.454
Long exposure	Can name long illness	0.028*
Long impact	Long impact fatal	0.382
Long impact	Can name long illness	0.049*
Long impact fatal	Can name long illness	0.732
	Risk Behavior Variables	
Protective measures	Protect clothing	0.000*
Protective measures	Protect washing	0.031*
Protect clothing	Protect washing	0.533

* statistically significant relations.

Table 3. Discrete Demographic Data of Interview Participants (*n*=40)

Variable	Frequency	Percentage
Sex of respondent		
Male	39	97.5
Female	1	2.5
Highest Level of Education		
No formal education	3	7.5
Less than elementary school	3	7.5
Less than middle school	7	17.5
Less than high school	18	45
Received high school diploma	7	17.5
Some college	1	2.5
Bachelor's degree	1	2.5
English Proficiency		
Not at all	19	47.5
A little	9	22.5
Some	9	22.5
A lot	2	5
Fluent	1	2.5

Table 4. Continuous Demographic Data of Interview Participants (*n*=40)

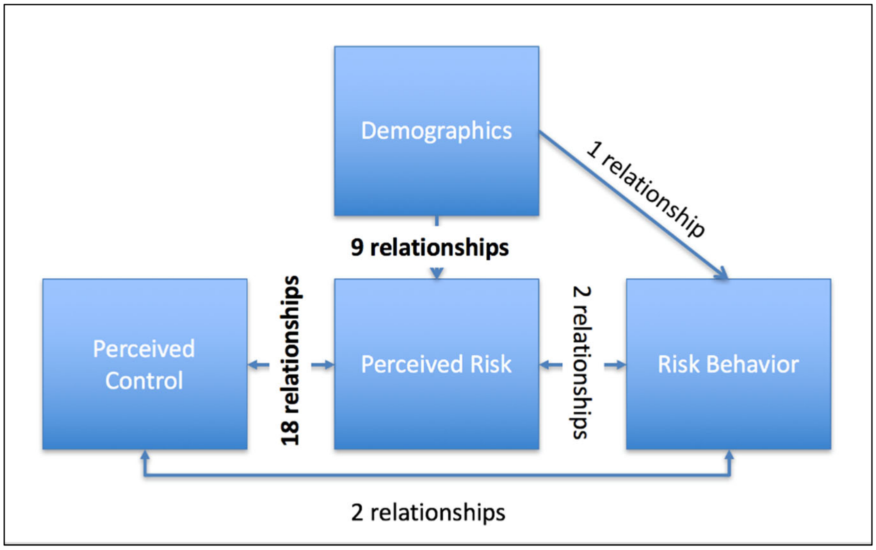
Variable	Minimum	Maximum	Mean
Age	20	72	38.32
# of farms	1	8	3.525
# of trainings	0	7	2.846
Ag duration in US	0	46	13.00
Ag duration before US	0	46	14.05
Total ag duration	0	72	26.43

Note: Age was used for farmworkers who indicated that they spent their entire life working in agriculture.

Results

The results—descriptive, cross-tab, and qualitative—reveal a number of important insights. First, descriptive demographics show that the majority of respondents are men, most have not completed high school, and about half are not proficient in English (Table 3). The age of respondents ranged from 20 to 72 years, with a mean age of 38 (Table 4). Second, the cross-tab analysis reveals a number of statistically significant correlations (Figure 3) that were of medium (V≈0.3) to large (V≈0.5) magnitude, indicating that the variables were significant and moderately or strongly correlated. The cross-tab results also show that demographics influence perceived risk (9 statistically significant relationships), and perceived risk is strongly correlated with perceived control (18 statistically significant relationships). There are fewer correlations between risk behavior and demographics, perceived risk, and perceived control (1, 2, and 2, respectively), as only two risk behavior questions were asked. Nonetheless, there are important insights to be gleaned from these few relationships. Third, the qualitative analysis, which consisted of paying attention to statements made by farmworkers, introduced the researchers to certain concerns that had not been captured through the statistics.

Figure 3. Conceptual Model with Results of the Current Study
There were 8 total demographic questions, 15 perceived control questions, 12 perceived risk questions, and 2 risk behavior questions in the questionnaire instrument.



Relationships between Demographics and Control, Perception, Behavior

Demographic factors relate strongly to perceived risk. What is immediately apparent is that farmworkers who might be the most systemically marginalized (those who have to travel to many farms in a year, those who have worked longer in menial jobs, and those who did not disclose their visa status) have a heightened sense of risk perception compared to their respective counterparts (those who work at fewer farms, have worked fewer years, and have disclosed their legal visa status) (Table 5).

Such marginalization might, as Bickerstaff (2004) found in her study on air pollution, cause heightened risk perception and vulnerability. However, our findings are nuanced. For example, farmworkers receive training when they first arrive at a farm; thus, the number of farms they work at correlates with the number of trainings, suggesting that those working at more farms might also be receiving the most education on pesticide risk exposure. Arcury et al.'s (2002) HBM analysis of farmers in North Carolina found that such trainings increase levels of perceived risk. In general, our findings also indicate, not surprisingly, that those with formal education tend to have a higher risk perception (Table 5), thus reiterating that education—whether in the form of trainings or otherwise—makes farmworkers more aware of pesticide risk hazards.

Interestingly, Arcury et al. (2002) did not find any correlations between demographics and perceived risk; however, our results definitely do find such correlations, aligning more with studies such as that of Damalas and Hashemi (2010) who statistically analyzed the results of 148 interviews with cotton growers in Brazil. Similar to their results, we find that younger farmworkers have higher perceived risk than older farmworkers. Specifically, younger farmworkers (<40 years old) were more likely to report having experienced a pesticide-related illness than older farmworkers ($\geq$40 years) (52.2% and 11.8%, respectively) (*p*=0.017; V=0.419). Younger farmworkers also have higher rates of perceiving that short-term pesticide exposure can result in an adverse health impact compared to older farmworkers (73.7% and

Table 5. Nature of the Relationship between Several Demographic and Perceived Risk Correlations Conducted through Cross-tab Comparisons

Demographic Variable	Perceived Risk Variable	Fisher's Exact *p*-value	Cramér's *V* significance	Nature of Relationship
# of farms (*1-4/5-8*)	**Experienced pesticide illness** (*yes/no*)	0.031	0.386	Farmworkers who worked at more farms experienced more pesticide-related illnesses.
# of farms (*1-4/5-8*)	**Short-term pesticide risk** (*yes/no*)	0.008	0.488	Farmworkers who worked at more farms were more likely to acknowledge that short-term pesticide exposure could result in an illness.
US Ag duration (*<15/15+*)	**Experienced pesticide illness** (*yes/no*)	0.001	0.509	Farmworkers who worked longer in U.S. agriculture had lower rates of reporting experiencing a pesticide-related illness.
Visa (*disclosed work visa status/did not disclose work visa status*)	**Others' health** (*cause concern, worry/not at all, no concern*)	0.034	0.408	Farmworkers who did not disclose their work visa status are more likely to be worried for the health of other workers with regards to exposure.
Education (*none/formal education)*	**Child health** (*cause concern, worry/not at all, no concern*)	0.034	0.424	Farmworkers who have received a formal education are more likely to be concerned for the health of children of farmworkers.
Education (*none/formal education)*	**Can name long-term illness** (*yes/no*)	0.022	0.435	Farmworkers who have received a formal education are more likely to be able to name an illness associated with long-term pesticide exposure.

33.3%, respectively) (*p*=0.006; V=0.404).

The reasons why this is the case are not completely intuitive: younger farmworkers might be better educated on the possible harms associated with pesticide use or be less aware of how to engage in safety behaviors. However, our findings indicate that, as high risk perception is not correlated with factors like education and safety training, younger farmworkers might not be more or less educated than their older counterparts. Instead, like Damalas and Hashemi (2010) indicate, perhaps what we are seeing is that they might be less inclined than their older counterparts to overlook the harms associated with pesticide exposure.

While perceived risk correlates strongly with demographics, there were no statistically significant relationships between demographics and perceived control variables, and there was only one significant relationship between demographics and risk behavior. Farmworkers who did not disclose their working visa status engage in protective safety measures at higher rates than farmworkers who *did* disclose their working visa status (93.8% and 62.5%, respectively) (*p*=0.018; V=0.378) (Appendix B, Table B1). One potential explanation for this relationship is that farmworkers who disclosed their visa statuses might have put more faith in their employer's role in mitigating the risk of pesticide exposure as there is more government regulation and oversight for documented workers than for undocumented workers. This explanation is supported by Arcury, Quandt, Cravey, Elmore, and Russell (2001), who also found that workers with H-2A work visas were more likely to indicate that there was safety support in their work environments than workers without H-2A visas.

Finally, our descriptive and qualitative results also reveal how farmworkers often categorize themselves as outside of risk, while they might categorize others at risk. For example, while few farmworkers (4) directly attributed the risks associated with pesticide exposure to those who actually apply the pesticides, many failed to articulate that, as farmworkers, they themselves face risk of exposure. For example, 10 farmworkers did not believe they were at short-term risk, though they agreed such risks do exist; similarly, 17 farmworkers responded that they believe pesticides can put one at long-term risk, but that they themselves are not at risk. Eight farmworkers indicated that, though others were at risk, they personally were not (Questions 27a and b). For example, when asked about his concern for his own health, one farmworker first responded with, "I've never had any problems" (translated). When asked about his concern for the health of his co-workers, he continued, "there's some that get a little sick, they take them to the clinic. We are not all the same. I don't worry about it because the cases are rare" (translated).

In all, our results show the important relationship between demographics and perceived risk, which in turn can help us target specific recommendations for pesticide safety as outlined in the discussion section.

Relationships between Perceived Control and Perceived Risk

As with numerous other studies (Arcury et al., 2002; Elmore & Arcury, 2001; Levesque & Arif, 2014), our results also point to the important ways in which perceived control correlates with perceived risk. Specifically, whether their employers will listen to them, whether they perceive pesticides as safe when used correctly, their own sense of personal responsibility, and the number of trainings farmworkers receive are all perceived control factors that show significant statistical relationships. The first two—whether their employers will listen and whether pesticides are safe when used correctly—indicate inverse relations between perceived control and perceived risk; for example, those who feel less in control over the safety of pesticides or their ability to be heard are those who perceive higher risk (Table 6). Cabrera and Leckie (2009) similarly note how perceived control is inversely related to perceived risk.

Our qualitative analysis shows that farmworkers often elaborated on their negative perception of control by noting that adverse health impacts are also dependent on the strength of the pesticide used or the competency of the pesticide applicators. Further, two workers noted the problems they face when they have to work in adverse weather, a

Table 6. Nature of Relationship between Several Perceived Control and Perceived Risk Correlations Conducted through Cross-tab Comparisons

Perceived Control Variable	Perceived Risk Variable	Fisher's Exact *p*-value	Cramér's *V* value	Nature of Relationship
Listened by employer (*yes/no*)	**My health** (*cause concern, worry/not at all, no concern*)	0.045	0.435	Farmworkers who believe they will be listened by their employer are less likely to be concerned about the effects of pesticides on their health.
Pesticides safe when used correctly (*yes/no*)	**Frequency of pesticide contact** (*never, rarely/sometimes, often, always*)	0.019	0.461	Farmworkers who perceive pesticides are not safe when used correctly report more frequent contact with pesticides.
Pesticides safe when used correctly (*yes/no*)	**Experienced pesticide illness** (*yes/no*)	0.005	0.528	Farmworkers who perceive pesticides are not safe have higher rates of reporting having experienced a pesticide-related illness.
Pesticides safe when used correctly (*yes/no*)	**Seen residue** (*yes/no*)	0.012	0.504	Farmworkers who perceive that pesticides are not safe have higher rates of reporting having seen pesticide residue on crops.

factor they cannot control. For example, rain often causes the pesticide residue to run off the crops and stain workers' clothing. In addition, hot weather heightens the occurrence of headaches and watery eyes. One farmworker noted: "If you're working in the rain and the rain makes the leaves wet, the pesticides run off and stain you…The videos don't tell you how to protect yourself [from this]" (translated).

Conversely, our statistical results show at least seven other inverse relationships where higher perceived control, specifically pertaining to the availability of soap and drinking water and the separation of handwashing water and drinking water, translated to lower perceived risk (Appendix B, Tables B2–B8). These results suggest that farmworkers do appreciate having access to basic safety measures, which ultimately increases their sense of self-efficacy. This finding is also confirmed by Arcury et al. (2002) and Remoundou et al. (2015).

We also see positive relations between perceived control and perceived risk. Those with a greater sense of personal responsibility with regard to the extent of their exposure (a form of self-efficacy) were more knowledgeable about both short-term and long-term pesticide exposure than those who did not identify themselves as being responsible (69.2% and 50%, respectively, for short-term exposure and 100% and 55.6%, respectively, for long-term exposure) (short-term: p=0.046; V=0.338) (long-term: p=0.004; V=0.454) (Appendix B, Tables B9 and B10). Further, workers who received more trainings during the year have higher rates of reporting having experienced a pesticide-related illness than farmworkers who have received fewer trainings (64.3% for farmworkers who received 4 to 7 trainings and 19.2% for farmworkers who received 0 to 3 trainings) (p=0.043; V=0.451) (Appendix B, Table B11).

Despite these positive relationships between trainings and perceived control, almost none of the farmworkers referred to the safety training video when answering risk perception or risk behavior questions later in the interview, suggesting that this form of training might not be memorable. In contrast, one farmworker kept referring to a "lady" who spoke with them about pesticide safety following the instructional safety video and was able to refer to her training when answering questions such as Questions 27a and c, *My health is hurt by pesticides* and *The health of the children of farmworkers is hurt by pesticides*, and Question 34, *Please list illnesses you believe can result from long-term pesticide exposure*. Thus, a human supplement to the instructional safety videos appears to have been more memorable than the video.

Overall, just as in other studies (Arcury et al., 2002; Elmore & Arcury, 2001; Levesque & Arif, 2014), our results highlight that perceived control is statistically significant in understanding perceived risk, and factors such as self-efficacy and cues to action do appear to have an impact on how safe farmworkers feel.

Relationships between Perceived Control and Risk Behavior

The significant relationships we see between perceived control and risk behavior are illuminating. For example, similar to Arcury et al. (2002) and Remoundou et al. (2015), our findings show that those who are more knowledgeable about the risks of pesticide exposure report higher rates of engaging in protective measures. Comparable to Arcury et al. (2002), whose study highlighted a correlation between perceived risk and the presence of restricted entry signs, we see that the presence of restricted entry signs correlates to an increase in the rate at which farmworkers use clothing as a protective measure against pesticide exposure compared to when there is an absence of restricted entry signs (93.1% and 40.0%, respectively) (p=0.040; V=0.412) (Appendix B, Table B12).

Interestingly, despite statistically significant correlations that show that the availability of soap leads to a sense of lower perceived risk (Appendix B, Tables B2–B4), its presence did not necessarily translate to an increase in washing, an important safety measure. Instead, counterintuitively, higher rates of soap availability translate to lower rates at which farmworkers engage in washing both themselves and their clothing as a protective measure against pesticide exposure (36.36% for frequent soap availability and 85.7% for infrequent soap availability) (p=0.033; V=0.377) (Appendix B, Table B13). The study conducted by Snipes et al. (2009) similarly discusses complicated behavior regarding using water as a preventative measure, noting that both a lack of knowledge and certain circumstantial barriers influence why farmworkers might not engage in such safety measures. For example, some farmworkers might delay washing, even if soap is available, due to the belief that one would get sick if they wash while their body temperature is too warm—a belief that several farmworkers (5) in the current study noted.

Our qualitative analysis adds further insight on why farmworkers might not engage in safety behavior, even when they know they might be at risk. For example, one farmworker noted that the safety trainings were not effective; although the safety training videos preached using gloves and masks during work, they were not actually provided with these safety materials. In fact, while many farmworkers (29) indicated that they should cover their bodies and mouths when working (Q37), at least four farmworkers indicated the difficulty of following recommendations. One farmworker commented, “with blueberries, you could cover your mouth to not get dust in; in apples, you can’t cover your mouth because it’s hard work and you’d get more tired with your mouth covered” (translated). Another farmworker also noted that the “dust” (pesticide residue) affects the eyes, but it is not possible to cover one’s eyes while working. This farmworker also experienced a burning sensation in the eyes after working in the fields. Similarly, one of the protective safety measures that many farmworkers mentioned was washing their work clothes. However, when asked about the presence of laundry facilities in the migrant camps (Question 39), only 37.5% of respondents said that laundry facilities were always provided, and 22.5% said they were never provided. There also appear to be discrepancies in reported waiting periods after a pesticide has been applied and before a farmworker can reenter that area. Some workers (5) indicated that this period is only 6–48 hours, while others (8) indicated they had to wait 3 days to 2 weeks. A couple of the farmworkers were illiterate and indicated that they were unable to read the restricted entry signs or written safety materials and/or instructions.

These farmworkers’ comments clearly spotlight the barriers to engaging in risk-mitigating behavior when gear and equipment are not always available or when safety instructions are not adequately communicated. As with previous studies (Arcury et al., 2002; Elmore & Arcury, 2001; Levesque & Arif, 2014), we see that many farmworkers sense an absence of control over their environments despite having awareness of pesticide exposure risk. For example, protective clothing is often hard to use, laundry facilities may not be present, and work must continue no matter what the weather.

Relationships between Perceived Risk and Risk Behavior

There are two identified relationships between perceived risk and risk behavior, specifically with regard to farmworkers' engagement in protective safety measures such as washing. Perceived risk acts as a modifying factor for risk behavior, as farmworkers who can name an illness associated with long-term pesticide exposure engage in pesticide safety protective measures at higher rates than those who cannot (96.4% and 66.7%, respectively) (p=0.022; V=0.412) (Appendix B, Table B14). Likewise, farmworkers who can name an illness associated with short-term pesticide exposure engage in washing as a protective safety measure at higher rates than those who cannot (66.7% and 27.3%, respectively) (p=0.024; V=0.394) (Appendix B, Table B15). These findings correspond to those of Remoundou et al. (2015), who found that risk perceptions play a role in affecting risk behaviors for farm operators, specifically for those whose health has been negatively affected by pesticides. In contrast, Cabrera and Leckie (2009) found that, despite being aware of the potential health impacts of pesticide exposure and having higher levels of risk perception than the general public, farmworkers continued to engage in unnecessary risky behaviors; they reason, as we also suspect through our findings discussed in the previous section, that perceived control can be a confounding factor.

Overall, our cultural risk assessment reveals important insights that confirm observations present in many earlier studies. While trainings and educational materials are valuable to help build awareness of risk perception, systemic factors, such as a lack of control over their circumstances, make it hard for migrant farmworkers to engage in safe behavior. Further, when put in conversation with technical risk assessment, we find additional barriers to ensuring farmworker safety.

Discussion

As the first study of its kind in Pennsylvania—a mixed method cultural risk assessment in dialogue with a technical risk assessment—our study's results yield many useful insights. These insights are important both because they are the first to focus on migrant farmworkers in Adams County—the nation's sixth-largest apple-producing region—and because they are applicable to understanding pesticide risk-management practices across the nation. Most notably, the quantitative analyses tease out important relationships between demographics, perceived risk, perceived control, and risk behavior, while our qualitative analysis provides additional information that can help explain reasons underlying some of these relationships. When placed in dialogue with technical risk assessment, they highlight further concerns about government standards for pesticide risk exposure policies, which should not be ignored if we are to safeguard both farmworkers and consumers.

Relationship between Cultural Risk Assessment and Technical Calculations of Risk

As described in the introduction, while the EPA has several calculations for determining exposure (Pederson, 1997; U.S. EPA, 1994, 2007; U.S. EPA Office of Pesticide Programs, 2002, 2013; U.S. EPA Office of Superfund Remediation and Technology Innovation, 2004), these are based on a series of generalizable assumptions with many limitations. These limitations become more clear when one considers the findings of our cultural risk assessment. For example, there is no easily available published or reported way to quantify the *interaction* and *cumulative exposure* of different pesticides. According to the U.S. Department of Agriculture's National Agricultural Statistics Service, 143 different chemicals (i.e., fungicides, herbicides, insecticides, etc.) were applied to Pennsylvania apple orchards in 2015, with most orchard farmers using between 20 and 50 different products in a given season. While it is not likely that all 143 chemicals were applied to every apple orchard, chemical interactions are likely to occur. Additionally, farmworkers indicated that they travelled to up to eight farms over the course of the year (Table 2).

According to the cross-tab analysis, farmworkers who worked at more farms had higher perceived risk, specifically with regard to reporting having experienced a pesticide-related illness (Table 4) and knowledge of the impacts of short-term pesticide exposure (Table 4). If farmworkers who are working at more farms during the year *and* are thus exposed to pesticides for blueberries or oranges in addition to those for apples, we can assume that the resulting higher rates of experiencing a pesticide-related illness could potentially be attributed to the interaction of a diverse variety of chemicals. A recent study regarding the interaction of pesticides in California identified several concerning health effects: decrease in the body's detoxifying ability, altered or damaged DNA, and limited DNA repair and expression enzymes (Zaunbrecher, Hattis, Melnick, Kegley, Malloy, & Froines, 2016). Equally concerning, the California study only looked at the interaction of three pesticides, nowhere near the 20–50 products that a Pennsylvania orchard farmer may use in one season.

Likewise, there are interactions between pesticides and other external factors, such as heat or moisture, that are not considered in the EPA's calculation of risk (Arcury, Vallejos, Marín, Feldman, Smith, & Quandt, 2006). As evident through the qualitative analysis, a farmworker noted that rain could cause the pesticide residue to run off the crops, stain worker clothing, and thus increase dermal exposure. Not only is this a limitation that the EPA does not consider, but it also offers evidence of the limitations of a technical risk assessment and highlights the importance of a cultural risk assessment, thus acknowledging the on-the-ground voices of those on the frontlines of our agricultural system.

Limitations

There are two primary types of limitations to this study: (1) sample size and representativeness of the sample, and (2) survey design and data collection.

Sample size and representativeness of the sample

The study is limited in size and scope as it has a small sample size (40 farmworkers) and a small representative sample of Adams County (only 13 of the 92 total camps in Adams County were visited). The LIU Migrant Education program noted that there are a variety of workers in different living situations, such as farmworkers who have year-round employment and have permanent residences that are *not* provided by the employer. Our sample was too small to compare the experiences of farmworkers across camps, and it did not account for different living conditions. For example, some of the visited camps were clean and had laundry facilities, while others were dirty or had broken or flea-ridden furniture. As Arcury et al. (2002) indicate, the variation of living conditions can influence perceived risk and perceived control; thus, additional research incorporating more farmworkers in different living situations will be valuable to assessing perceived control and perceived risk in Pennsylvania farmworker communities.

In addition, there was a marked absence of women and children in the camps, and thus less opportunity to interview women workers and compare risk based on gender. Based on other studies (Anthony, Williams, & Avery, 2008; Cabrera & Leckie, 2009; Peres, Rodrigues, da Silva Peixoto Belo, Moreira, & Claudio, 2013; Remoundou et al., 2015; Snipes et al., 2009) that take gender into consideration, we can hypothesize that including women in future studies will yield important comparative insights. For example, the responses could differ, specifically for question 27c: *The health of the children of farmworkers is hurt by pesticides*. We observed during data collection that female farmworkers were always accompanied by children in the camps, while male farmworkers were almost never accompanied by children, which leads us to believe that we might see greater concern for children by women farmworkers, as observed in Snipes et al. (2009).

Survey design and data collection

Similar to many other studies that apply the HBM framework, our use of the model is relatively simplistic, a consequence of the fact that we are operating with a small sample size. Consequently, we are not able to analyze correlations between variables within perceived risk—for example, susceptibility and severity, or severity and benefits. Such analyses would be a rich area of potential future research within the context of a larger, more comprehensive survey. Also, like most previous research (Arcury et al., 2002; Quandt et al., 2001; Snipes et al., 2009), this study does not evaluate complex interactions between HBM variables. To do so would require not only a larger survey but a re-working of the HBM model to articulate the ordering of variables (Jones et al., 2015), which is beyond the scope of this study.

Furthermore, because we only have two risk behavior questions, we are not able to draw many conclusions about relationships between perceived risk or perceived control variables and risk behavior variables. To dig deeper into relationships with risk behavior, a future survey could ask open-ended risk behavior questions (e.g., *Please list safety measures that you take to reduce any possible harmful effects of pesticide exposure*) and then ask when the farmworker engages in risk behaviors. Asking such directed questions would align better with studies such as Arcury et al. (2002) and Snipes et al. (2009), but unfortunately was not feasible in this short survey.

Conclusion and Future Directions for Pesticide Risk Research and Mitigation

Literature on risk assessment, particularly the HBM model, shows that people must first perceive themselves to be at risk in order to take mitigating action, and this is the case in our study. More knowledge of specific pesticide risks by farmworkers does correlate with higher rates of reported preventive risk action. However, our results also indicate that it is not always possible for farmworkers to take preventive action due to the lack of control they have over their environments (e.g., the availability of laundry facilities and protective gear such as gloves and face masks, and the inconvenience of weather). While these findings are consistent with previous studies (Arcury et al., 2002; Cabrera & Leckie, 2009; Elmore & Arcury, 2001; Remoundou et al., 2015; Snipes et al., 2009), they provide a clear basis for recommendations in Adams County, Pennsylvania, that can be extended across the nation, especially in terms of what researchers might do to assist in pesticide mitigation strategies.

First, our study's significant correlations between certain demographics (age, education, visa status) and perceived risk provide new insight which is particularly relevant to recommending practices for safer pesticide use. More specifically, while we cannot control the demographics of farmworkers, we can target specific demographics to ensure that all farmworkers feel (and are) protected in their work. This is where researchers can be particularly valuable. For example, we can target older farmworkers differently than younger farmworkers. By facilitating focus groups that tease out the nuances of each demographics work and safety concerns, we can better understand their different risk perceptions. Such additional research is an essential first step to draft safety recommendations that each demographic might employ in their daily lives. Likewise, we can target farmworkers who have not received a formal education and workers who are registered with an H-2A work visa to better understand the reasons for their lower risk perception compared to their counterparts (those with formal education and those without legal status). Second, we must also seriously consider how technical risk assessment is evaluated. It is imperative that there is more clinically based research regarding the effects of chemical interactions, cumulative exposure, and weather on pesticide exposure and absorption. In both recommendations concerning how to increase pesticide knowledge, we encourage the community-based research (CBR) framework, which ensures that stakeholder needs and values are considered. Although we did not employ CBR in its entirety, as stakeholders were not consulted in the creation of the survey instrument, our research was based on the invitation of community partners; we sought to respect and validate the knowledge of stakeholders, and our findings are shared with community members in a variety of ways to help prompt change in factors that determine stakeholder safety. These included two oral presentations—one public presentation attended by the LIU partners and another given to the Adams County Food Policy Council, which includes local partners such as the local Penn State Agricultural unit that liaisons with farmers. The results will also be shared freely in written form.

Some recommendations for community members working on the ground include the following possibilities. First, most farmworkers indicated that only one training session was conducted when they first arrived at the Pennsylvania farm. Given that our results correlate greater awareness with more trainings, we recommend having at least one additional training over the course of the harvest season. Second, it is important to ensure that farmworkers are guaranteed a sense of control of their environment—whether this is in in the form of providing bilingual and visual-restricted entry signs for both literate and illiterate farmworkers, or in the form of other preventive actions, such as encouraging washing. For example, bilingual and visual signs for the use of soap in bathrooms coupled with verbal information about the value of washing as a safety precaution might be worthwhile, and the inclusion of laundry facilities by employers is also recommended. Third, our results suggest that bringing in a verbal communicator following the video trainings or switching to in-person trainers altogether may help build the credibility and trustworthiness of the pesticide safety instructions, which in turn can translate to safer behavior. Similarly, we recommend building trust between employer and farmworker by encouraging more dialogue and interaction; as our results indicate, farmworkers who believe their employers will listen to them have a higher sense of control. Overall, we understand that the political realities of agricultural exceptionalism can (and do) hamper the implementation of such recommendations by marginalizing migrant farmworkers in multiple ways. For example, having low-income or undocumented status make certain farmworkers more vulnerable to power dynamics (Gray, 2013; Holmes, 2013; Rodman et al., 2016; Weiler et al., 2016). However, we also recognize that advocating for change based on what farmworkers say is a first step towards ensuring that (1) farmworkers feel that they have control over their health, and (2) that perceived risk aligns with the actual risk they face from pesticide use.

Cultural risk assessment is an important first step in rebalancing inequities of power in our food system. The harms associated with pesticide risk exposure can be successfully mitigated with careful attention to the voices of those on the frontlines of our food system. Not only are more studies needed to fully assess the potential threat to the migrant population and illuminate and mitigate environmental injustices facing this community, but such studies are valuable to frame policies that can more effectively ensure farmworkers' safety.

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Appendix A. Survey Instrument, Reorganized by Risk Assessment Categories: Demographics, Perceived Control, Perceived Risk, Risk Behavior, and Technical Risk

	Question abbreviations used in cross-tab tables
Demographics Questions	
1. What is your age?	Age
2. What is your gender?	Gender
3. What is the highest level of education you have achieved? What country did you receive this education?	Education
4. To what extent can you speak/understand/read English?	English
5. Where does your family originate?	Origin
6. How long have you been working in agriculture in the U.S.?	Ag duration US
7. How long have you been working in agriculture before you were in the U.S.?	Ag duration before US (Total Ag duration)
8. Where have you worked in the past year?	# of farms
Perceived Control Questions	
9. What was your housing situation(s)?	Housing
10. Do you like working in agriculture?	Like Ag
11. If you were not working in agriculture, what is something else you would like to be doing with your time?	Alt. work
13. Do you get paid by the hour? Or by quantity?	Pay type
20. In the past year, how many times were you trained or provided with materials regarding pesticide safety?	# of trainings
21. Are you trained at every farm you work at?	Trainings everywhere
23. Are you told when pesticides are applied?	Told application
24. Are restricted entry interval signs posted? Are they in Spanish and/or English?	Restricted signs/Sign lang.
25. Does your employer speak (or have someone who can speak) Spanish?	Employer Spanish
26. Do you believe you would be listened to by your employer, the government, or an independent agency if you had concerns that your (or your family's) health was at risk because of your work in agriculture? Why/Why not?	Listened by Employer
35. Do you believe you have control over avoiding any possible effects of pesticides that can be harmful to your health?	Control
36. Do you agree with the following statement, "Pesticides are not harmful if used correctly"?	Pesticides safe
39. For the following questions, please indicate the frequency of which these activities occur:	
a. Soap is available for you in the fields	Available soap
b. Toilets are available for you in the fields	Available toilets
c. Drinking water is available to you in the fields	Available drinking
d. There are separate drinking and handwashing water	Separate water
e. You are required to eat in the fields	Eat in fields
f. You have access to laundry facilities in the camps	Available laundry
g. You are provided with showers and adequate plumbing	Available showers
h. Your employer has told you to dress/work safely	Employer talk safety
i. Your co-workers talk about safety	Co-workers talk safety
j. Your co-workers take safety precautions	Co-workers take safety
40. In the past year, how many times have you seen a physician or went to a healthcare provider?	Physician visits
43. Whose job do you think it is to primarily ensure that pesticides do not cause harm?	Responsibility (Self is responsible, Employer is responsible, Gov. is responsible)

Perceived Risk Questions	
19. How often do you have direct contact with pesticides?	Freq. pest contact
22. Do you believe these trainings/educational materials are effective in promoting your safety and health?	Effective trainings
27. Please indicate your answers to the following regarding your perception of health impacts:	
a. My health is hurt by pesticides	My health
b. The health of other farmworkers is hurt by pesticides	Others' health
c. The health of the children of farmworkers is hurt by pesticides	Child health
d. The health of unborn children of farmworkers is hurt by pesticides	Unborn health
e. The ability of farmworkers to have children is hurt by pesticides	Ability health
28. Do you believe your health is hurt by other work-related conditions? How have you seen health effects related to that?	Other work conditions
29. Do you believe short-term pesticide exposure can result in illnesses (direct or indirect exposure after several weeks)?	Short exposure
30. What short-term health impact does exposure have?	Short pest. Impact/Short pest. Impact fatal Can name short illness
31. Please list illnesses you believe can result from short-term pesticide exposure.	Long exposure
32. Do you believe long-term pesticide exposure can result in illnesses (direct or indirect exposure over several years)?	Long pest. impact
33. What health impact does long-term exposure have?	Can name long illness
34. Please list illnesses you believe can result from long-term pesticide exposure.	
38. Do you think the following activities reduce your pesticide exposure (yes/no/maybe)	Wash hands
a. washing hands: before eating, before drinking, before smoking, before using the toilet, after using the toilet	Wash clothes
b. washing work clothes: after 1 day in the field, separately from non-work clothes	Wear
c. wearing: gloves, boots, coveralls/overalls, chemical resistant clothing, bandana/head covering	Change clothes
d. changing clothes: before leaving work, upon immediate return from work	Shower
e. showering: before leaving work, upon immediate return from work	Pesticide illness
41. Have you experienced health outcomes/illnesses that you believe are directly related to pesticide exposure?	
Risk Behavior Questions	
37. Please list safety measures that you take to reduce any possible harmful effects of pesticide exposure.	Protective measures (Protective clothing, Protective washing, Protective avoid areas) When stop
42. Would you stop working in agriculture if your health was being compromised? At what point?	
Technical Risk Questions	
12. How many hours do you work each day on average? How many days a week?	Hours/days
14. What crop(s) did you work with in the past year (and where)?	Which crops
15. What were you primarily doing with the crops (pruning, harvesting)?	Crop activity
16. Do you know if pesticides were applied to the crops? How do you know?	Told application

17. Do you know any of the pesticide names?	Pest. Names
18. Do you know how the pesticides were generally applied (ground, aerial, sprinkler irrigation)?	Application method

Note: "Visa" (worker has a government-contracted work visa) and "Seen residue" (worker has indicated the presence of pesticide residue on crop) are abbreviated responses from farmworkers that were not explicitly asked in the survey instrument but were still used when conducting statistical tests.

Appendix B. Results: Cross-tab Comparisons

Demographics (variable 1) as Modifying Factor for Risk Behavior (variable 2)

Table B1. Cross-tab comparison of whether farmworkers have disclosed that they have an H-2A work visa (based on whether they return to Mexico during the year [Question 8]) and whether they engage in a protective safety measure (Question 37). *n*=40; Fisher's Exact p=0.046; Cramér's V=0.378.

Visa	Protective measures		
	Something	Nothing	**Total**
Disclosed work visa status	5	3	8
Did not disclose work visa status	30	2	32
Total	35	5	**40**

Relations between Perceived Control (variable 1) and Perceived Risk (variable 2)

Table B2. Cross-tab comparison of the frequency of reported soap availability in the fields (Question 39a) and whether they reported having experienced a pesticide-related illness (Question 41). *n*=40; Fisher's Exact *p*=0.039; Cramér's V=0.352.

Soap available	Pesticide illness		
	Yes	No	**Total**
Sometimes-rarely-never	5	2	7
Often-always	9	24	33
Total	14	26	**40**

Table B3. Cross-tab comparison of the frequency of reported soap availability in the fields (Question 39a) and whether farmworkers reported having seen pesticide residue (not asked in question). *n*=40; Fisher's Exact p=0.006; Cramér's V=0.494.

Soap available	Seen residue		
	Yes	No	**Total**
Sometimes-rarely-never	5	2	7
Often-always	5	28	33
Total	10	30	**40**

Table B4. Cross-tab comparison of the frequency of reported soap availability in the fields (Question 39a) and whether farmworkers can name an illness associated with short-term pesticide exposure (Question 31). *n*=40; Fisher's Exact p=0.033; Cramér's V=0.377.

Soap available	Can name short illness		
	Yes	No	**Total**
Sometimes-rarely-never	6	1	7
Often-always	12	21	33
Total	18	22	**40**

Table B5. Cross-tab comparison of the frequency of reported drinking water availability in the fields (Question 39c) and how frequently farmworkers reported having contact with pesticides (Question 19). *n*=39; Fisher's Exact p=0.000; Cramér's V=0.680.

Drinking water available	Freq. pest. contact		
	Rarely-never	Sometimes-often-always	**Total**
Sometimes-rarely-never	0	6	6
Often-always	28	5	33
Total	28	11	**39**

Table B6. Cross-tab comparison of the frequency of reported drinking water availability in the fields (Question 39c) and whether farmworkers reported having seen pesticide residue (not asked in question). *n*=40; Fisher's Exact p=0.002; Cramér's V=0.566.

Drinking water available	Seen residue		
	Yes	No	**Total**
Sometimes-rarely-never	5	1	6
Often-always	5	29	34
Total	10	30	**40**

Table B7. Cross-tab comparison of the frequency of reported drinking water availability in the fields (Question 39c) and whether farmworkers reported having experienced a pesticide-related illness (Question 41). *n*=40; Fisher's Exact p=0.001; Cramér's V=0.572.

Drinking water available	Pesticide illness		
	Yes	No	**Total**
Sometimes-rarely-never	6	0	6
Often-always	8	26	34
Total	14	26	**40**

Table B8. Cross-tab comparison of the frequency of separate handwashing and drinking water availability (Question 39d) and whether farmworkers perceive the safety trainings as effective in promoting their health (Question 22). *n*=37; Fisher's Exact p=0.027; Cramér's V=1.000.

Separate water	Effective trainings		
	Yes	No	**Total**
Never	0	1	1
Often-always	36	0	36
Total	36	1	**37**

Table B9. Cross-tab comparison of whether farmworkers perceive themselves as responsible for protecting themselves against pesticide exposure (Question 43) and whether they can name an illness associated with short-term pesticide exposure (Question 31). *n*=40; Fisher's Exact p=0.046; Cramér's V=0.338.

Self is responsible	Can name short illness		
	Yes	No	**Total**
Yes	9	4	13
No	9	18	27
Total	18	22	**40**

Table B10. Cross-tab comparison of whether farmworkers perceive themselves as responsible for protecting themselves against pesticide exposure (Question 43) and whether they can name an illness associated with long-term pesticide exposure (Question 34). *n*=40; Fisher's Exact p=0.004; Cramér's V=0.454.

Self is responsible	Can name long illness		
	Yes	No	**Total**
Yes	13	0	13
No	15	12	27
Total	28	12	**40**

Table B11. Cross-tab comparison of number of trainings farmworkers reported having over the course of the year (Question 20) and whether they reported having experienced a pesticide-related illness (Question 41). *n*=40; Fisher's Exact p=0.043; Cramér's V=0.451.

# of trainings	Pesticide illness		
	Yes	No	**Total**
0–3	5	21	26
4–7	9	5	14
Total	14	26	**40**

Relation between Perceived Control (variable 1) and Risk Behavior (variable 2)

Table B12. Cross-tab comparison of whether restricted entry signs are posted (Question 24) and whether they use clothing as a protective safety measure (Question 37). *n*=33; Fisher's Exact p=0.040; Cramér's V=0.412.

Restrict entry signs	Protective clothing		
	Yes	No	**Total**
Yes	27	2	29
No	2	3	5
Total	29	5	**34**

Table B13. Cross-tab comparison of the frequency of reported soap availability in the fields (Question 39a) and whether they use washing as a protective safety measure (Question 37). *n*=40; Fisher's Exact p=0.033; Cramér's V=0.377.

Soap available	Protective washing		
	Yes	No	**Total**
Sometimes-rarely-never	6	1	7
Often-always	12	21	33
Total	18	22	**40**

Relation between Perceived Risk (variable 1) and Risk Behavior (variable 2)

Table B14. Cross-tab comparison of whether farmworkers can name an illness associated with long-term pesticide exposure (Question 34) and whether they engage in some form of protective safety measure (Question 37). *n*=40; Fisher's Exact p=0.022; Cramér's V=0.412.

Can name long illness	Protective measures		
	Something	Nothing	**Total**
Yes	27	1	28
No	8	4	12
Total	35	5	**40**

Table B15. Cross-tab comparison of whether farmworkers can name an illness associated with short-term pesticide exposure (Question 31) and whether they use washing as a protective safety measure (Question 37). *n*=40; Fisher's Exact p=0.024; Cramér's V=0.394.

Can name short illness	Protective washing		
	Yes	No	**Total**
Yes	12	6	18
No	6	16	22
Total	18	22	**40**