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Pesticide Use and Safety Training in Mexico: The Experience of Farmworkers Employed in North Carolina

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Abstract

Migrant and seasonal farmworkers in the United States are now overwhelmingly immigrants from Mexico. Pesticide exposure among these farmworkers is a major occupational health concern; however, little research has considered the agricultural pesticide use and safety experiences of these workers in their communities of origin. This analysis uses survey data collected by the PACE project to delineate the farming and pesticide use experiences of Mexican-born farmworkers in North Carolina. Over 80 percent of the 277 Mexican-born farmworkers had done agricultural work in Mexico, including work on their own farms (93%) and as hired farm labor (35%). Almost two-thirds of those farmworkers with farming experience had used pesticides, but only about one-third of those who used pesticides had received pesticide safety training or information. Most of those who used pesticides had used some form of safety equipment. Those who had worked as hired farm labor in Mexico were more likely to have used pesticides and safety equipment, and to have received safety training and information. Those who spoke an indigenous language at home rather than Spanish were less likely to have used pesticides and to have received safety training and information. These results demonstrate that farmworkers coming to the U.S. from Mexico arrive with a variety of experiences with pesticide usage and pesticide safety training. Such experiences form the framework within which farmworkers understand the relationship of pesticide usage to human health. It is important for occupational health and safety programs directed to farmworkers in the U.S. to consider the experiences these workers bring from their communities of origin.

Keywords

migrant farmworkers; pesticide safety; agriculture; community-based research; Latinos; North Carolina

Pesticide exposure among migrant and seasonal farmworkers is a major occupational health concern in the United States (Arcury and Quandt 1998; Moses 1989; Moses et al. 1993). In response to these concerns, the U.S. Environmental Protection Agency has implemented the Worker Protection Standard for farmworker pesticide safety training (U.S.-EPA 1992), and the states have implemented specific field sanitation requirements for all persons who employ agricultural workers (for example, North Carolina Department of Labor 1995).

Most of the migrant and seasonal farmworkers in the U.S. are from Latin American countries, specifically Mexico (Mehta et al. 2000). Transnational agricultural labor in the U.S. has been considered in terms of its effects on immigration policy and law enforcement for undocumented immigrant workers (Hahamovitch 1997; Mitchell 1996), and in terms of the effects immigrants have on the communities in which they reside (Cravey 1997; Horowitz and Miller 1999). Research has not examined how the experiences these transnational workers bring with them from their communities of origin affect their adaptation to the work and safety milieu of the U.S. farms on which they work. The transnational character of agricultural workers is important for the occupational health and health education of these workers. These workers come to the U.S. with experiences, knowledge, and beliefs about occupational safety that must be considered in occupational safety requirements and education. In particular, many farmworkers may have used and been exposed to agricultural pesticides before immigrating to the U.S. (Hunt et al. 1999). In addition to the possibility of having experienced the effects of pesticide poisoning (Tinoco-Ojanguren and Halperin 1998), these workers may have established work behaviors and belief systems that affect their safety behaviors on U.S. farms and the type and content of safety education that they need (Hunt et al. 1999; Quandt et al. 1998).

While the potential health effects of pesticide exposure among farmworkers are significant (Arcury and Quandt 1998; Moses et al. 1993), and the work patterns of these workers in their countries of origin may affect their safety behaviors and attitudes toward safety education in the U.S., research on farmworker occupational health and safety has virtually ignored the premigration work experiences of these farmworkers. This analysis is a first step toward describing the agricultural pesticide experiences of farmworkers from Mexico in an effort to inform national and international pesticide safety programs.

In this paper we describe the level of pesticide use, safety training, and safety behaviors reported by a sample of migrant and seasonal workers from Mexico who work in North Carolina. We also delineate the variability in pesticide safety training and behavior in terms of farm work experience in Mexico, migration characteristics, and education and acculturation. This paper seeks to answer three basic questions about the migrant and seasonal farmworkers from Mexico who are employed in North Carolina relative to pesticide exposure. First, what are the agricultural experiences and demographic and migration characteristics of the Mexican-born migrant and seasonal farmworkers in North Carolina? Second, how many of the Mexican farmworkers in North Carolina have used agricultural pesticides in Mexico, and how many have received safety training and information? Finally, how does pesticide use, safety training, safety information, and safety equipment use vary by farm work experience in Mexico, migration experience, and education and acculturation among farmworkers from Mexico?

Background and Significance

There are an estimated 4.2 million seasonal and migrant farmworkers and their dependents in the United States, with 1.6 million classified as migrant (HRSA 1990). Migrant and seasonal farmworkers work in at least 42 of the 50 states. While some areas of the United States have routinely employed large numbers of seasonal and migrant farmworkers, other areas are experiencing a dramatic increase in these workers as family labor gives way to hired labor. Some areas of the U.S. are also experiencing change in the ethnicity of migrant and seasonal workers. For example in North Carolina, which ranks fifth in the size of its farmworker population, most farmworkers were African American until the late 1980s. Today only 10 percent are African American; most, like the rest of the U.S. farmworker population, are Latino (Mines, Gabbard, and Steirman 1997).

Data from the 1997–98 National Agricultural Workers Survey (NAWS) show that 90 percent of all migrant and seasonal farmworkers in the United States are Latino, and 77 percent of all U.S. farmworkers were born in Mexico (Mehta et al. 2000). In North Carolina, it is still possible to find camps in which all or most of the workers are African American or Afro-Caribbean, but these are rare and located in very specific regions of the state (e.g., in far northeast North Carolina African American workers pick watermelons). In a 1998 survey of 270 farmworkers in central North Carolina, Arcury et al. (1999a) found that all were Latino and 265 were born in Mexico. Many of these farmworkers came directly to North Carolina from Mexico, and they were not part of the East Coast migrant stream that starts in Florida. Several spoke one of the indigenous languages of Mexico.

Epidemiological research on actual farmworker exposure to pesticides in the workplace and the direct link of this exposure to health and disease is meagre. We know that direct exposure to large amounts of pesticides, as in the case of being directly sprayed in the field, drinking from mismarked containers, or being soaked from a spill, results in injury or even death. While such exposure appears to be rare, existing data may underestimate poisoning because few states have a mandatory surveillance system in place for reporting acute pesticide poisoning (Das et al. 1999; Maizlish, Rudolph, and Dervin 1995).

Most pesticide exposure occurs as exposure to residues, small amounts of chemicals that remain on plants and equipment. There is little information about the immediate (e.g., rashes) and long-term (e.g., cancer, neurological disorders, reproductive problems) effects for farmworkers of residue and low-level exposure. Zahm and Blair (1993) have explored developing procedures to investigate the long-term effects of pesticide exposure on farmworkers, but the task is formidable. A few studies provide some insights into farmworker low-level pesticide exposure. For example, Ciesielski et al. (1994) collected data from farmworker clinic patients in North Carolina and found depressed cholinesterase levels. However, these data did not show any specific health effects related to this indicator of organophosphate pesticide exposure. Due to these limitations in the research literature, Arcury and Quandt (1998:839) conclude,

that current data are insufficient to determine whether or not farmworkers are suffering negative consequences of chronic low level exposures to agricultural chemical residues. This is due primarily, however, to lack of good exposure

measures. It is important to note that these null results do not indicate no effect, but rather reflect the limits of our capacity to detect effects (Krieger 1995) and the relative lack of attention to developing measures for this disenfranchised population. Traditional epidemiologic measures connecting exposure and outcome at individual levels are largely unsuitable for establishing the consequences of exposure in this population. It is, therefore, both prudent and ethical to make every reasonable effort to reduce exposure of all persons to chemical residues, including farmworkers.

Pesticide exposure among farmworkers may be exacerbated by the increased proportion of farmworkers who are Latino. Many of these farmworkers do not speak English and have limited formal education, so providing them with pesticide safety education in the U.S. is difficult. It is unclear what level of work experience with pesticides these farmworkers bring with them, or the level and quality of pesticide safety training they have had. The U.S.-EPA Worker Protection Standard (U.S.-EPA 1992) requires educating agricultural workers in pesticide safety. However, these training requirements ignore any experiences workers may have had in their countries of origin.

Analyses of farmworkers' beliefs and knowledge about pesticide exposure and safety (e.g., Lantz et al. 1994; Quandt et al. 1998), while few in number, indicate that safety training must address these workers' cultural models of pesticide safety. The cultural model of pesticide safety held by Mexican farmworkers in North Carolina includes: 1) the belief that pesticides must be seen, tasted, or smelled to be present; 2) the belief that some individuals are strong (usually the person being interviewed) and so not affected by pesticide exposure, while other individuals are weak (in particular women) and are easily affected by pesticides; and 3) no recognition of the existence of residues or the potential ill effects of exposure to these residues (Quandt et al. 1998). These cultural models of pesticide safety appear to be based on their experiences in their countries of origin. In an independent analysis of agricultural worker pesticide safety beliefs in Chiapas, Mexico, Hunt and her colleagues (1999) report a cultural model very similar to that found by Quandt et al. (1998).

There is a growing body of literature demonstrating that agricultural workers and their families are exposed to pesticides in developing countries (Perfecto 1992). For example, Andreatta (1998) discusses the causes of pesticide exposure among Caribbean banana farmworkers. McConnell and Hruska (1993) use data from Nicaragua to support their conclusion that there is an "epidemic" of agricultural pesticide poisoning in developing countries due to the wide availability of chemicals that are restricted or banned in developed countries and the manual application of these pesticides. Guillet et al. (1998) present strong evidence that agricultural pesticide exposure is having negative neurological effects on farm children in Sonora, Mexico. Tinoco-Ojanguren and Halperin (1998) demonstrate the high levels of agricultural pesticide exposure among *campesinos* in Chiapas, Mexico, and document the effects of this exposure in terms of depressed cholinesterase levels. Waliszewski and colleagues (1999a, 1999b; Pardo et al. 1998) show that the high level of pesticide use in Veracruz, Mexico, has resulted in pesticides being detectable in nonagricultural populations. Wright (1990) presents a detailed political economic analysis of pesticide use in Mexico in *The Death of Ramon Gonzalez*. However, there is no

documentation as to whether the farmworkers in North Carolina and the remainder of the U.S. are recruited from among the Latin American agricultural workers who are exposed to pesticides in their home countries.

Methods

The data used in this analysis were collected in 1999 as part of the PACE (Preventing Agricultural Chemical Exposure among North Carolina Farmworkers) Project. The PACE project was a community-based participatory research project designed to reduce exposure of farmworkers to pesticides and other agricultural chemicals by developing, testing, and disseminating culturally appropriate interventions (Arcury et al. 1999a; Arcury et al. 2000; Quandt et al. 2001). The North Carolina Farmworkers' Project (NCFP), a community-based farmworker advocacy organization, was a partner in PACE, participating in all research and intervention activities. The PACE project was based in an eight-county region of central North Carolina. Agricultural production in these counties includes tobacco, cucumbers, sweet potatoes, cotton, and a number of other fruit and vegetable crops. The eight-county study area included the counties with the state's highest concentrations of farmworkers.

Data for this analysis came from preintervention interviews conducted for the PACE project with 293 Latino farmworkers during June and July 1999. A two-stage approach was used to locate and recruit participants (Arcury et al. 1999b). The sampling and recruitment strategy design was based on the need to maximize the representativeness of the sample, while taking into account the exigencies of working with a largely undocumented, relatively "invisible," and highly mobile population. Because the number of farmworkers and their distribution in North Carolina, as in many states, were unknown, there was no available sampling frame. Based on information obtained during earlier research and provided by the NCFP, we knew workers could be located in a variety of residential sites, including on-farm labor camps, trailer parks, old farm houses, and apartments. The first stage of the sampling plan was intended to maximize representativeness of the sample by selecting a broad range of sites. A site was defined as a residential locale in which all or most residents were farmworkers and their families. To identify as many sites as possible, community representatives connected with the NCFP helped create a list of potential sites. They did this based on their knowledge as area residents, by community reconnaissance, by interviewing farmers, and by talking with farmworker service providers. The next step was to visit each site and ascertain that the farmworkers present would be willing to participate in the study, if asked. Community members, Latino former or current farmworkers, were hired and accompanied the project coordinator on site visits. The PACE staff then selected a mix of sites from those visited, including large and small labor camps, trailer parks, and rental housing.

Thirty-six sites were included in the first stage of the sample. One site originally selected for the study was dropped and replaced when the farmer who owned the site refused to have his employees participate. In the second sampling stage, farmworkers were recruited at each site. For the 33 sites with fewer than 10 workers, all site residents were asked to participate. In the other three sites, the following procedure was used to select at least 10 respondents. After a brief general presentation to the group, the interview team leader identified workers to be interviewed. The criteria used were to first select any women present and then to select

a range of ages from those present. Using this system of multiple contacts leading up to recruitment familiarized farmworkers with the project; there were very few refusals at the stage of actual recruitment.

The interview questionnaire was developed in English as well as Spanish. Whenever possible, items were taken from existing instruments. A professional service translated all new items into Spanish; these items were then reviewed and edited by native Spanish speakers. The entire questionnaire was then pretested with farmworkers residing in the study area.

Interview teams included professional staff members, college students, and former farmworkers. All were fluent in Spanish. The former farmworkers were originally from Latin America and currently live in the study area. All interviewers attended training at two three-hour sessions. Interviews took approximately 25 minutes to complete. Participants were given information about the study and interview, and asked for consent. At the end of the interview, participants were given a T-shirt printed with a safety message. No mention was made of the incentives before the interview to ensure that they were not inducements to participate.

The entire sample was screened with two questions. Was the farmworker born in Mexico? Had he or she done farm work in Mexico? If a respondent answered yes to both, data were collected on pesticide use and farming in Mexico.

There were four primary pesticide use and safety variables for this analysis: 1) used pesticides in Mexico; 2) received pesticide safety training in Mexico; 3) received pesticide safety information in Mexico; and 4) used pesticide safety equipment in Mexico. Respondents who said they had received pesticide safety training or information in Mexico were also asked from whom the training or information was received. Respondents who stated they had used pesticide safety equipment in Mexico were also asked what types of equipment they used.

Pesticide use in Mexico is a dichotomous variable based on the positive or negative response to the question, “Did you use pesticides in Mexico?” (“¿Utilizó pesticidas en México?”). *Received pesticide training* in Mexico is a dichotomous variable based on a positive or negative response to the question, “Did you receive any pesticide safety training in Mexico in which someone talked to you about ways to work safely with pesticides or showed you a video about pesticide safety?” (“¿Participó usted en algún entrenamiento de protección contra los pesticidas en México, en el que alguien le haya platicado sobre cómo trabajar de una manera segura con los pesticidas, o le haya mostrado un video sobre la protección contra los pesticidas?”). Those who responded that they had received pesticide training in Mexico were then asked from whom this training was received and read a list that included the person who sold the pesticides, health care provider, family member, friend, employer, and other (“vendedor de los pesticidas, un proveedor de cuidado de la salud, un miembro de la familia [pariente], un amigo, el empleador, otro”). Respondents were told they could select more than one source of training. *Received pesticide information* in Mexico is a dichotomous variable based on a positive or negative response to the question, “Did you

receive any pesticide safety information in Mexico, such as brochures or pamphlets? (“¿Le dieron alguna información sobre la protección contra los pesticidas en México, como por ejemplo, folletos o panfletos?”). Those who responded that they had received pesticide information in Mexico were then asked from whom this information was received and read a list that included the person who sold the pesticides, health care provider, family member, friend, employer, and other; respondents were told they could select more than one source of training. *Used pesticide safety equipment* in Mexico is a dichotomous variable based on a positive or negative response to the question, “Did you use any safety equipment when you worked with pesticides in Mexico?” (“¿Utilizó algún tipo de equipo de protección cuando trabajó con pesticidas en México?”). Those who responded that they had used safety equipment in Mexico were then asked what equipment they had used and read a list that included mask, goggles, gloves, hat, suit, and other (“mascarilla, gafas protectoras, guantes, sombrero, traje protector, otro”). Respondents were told they could select more than one type of safety equipment.

The farmworker background variables considered in this analysis fall into four groups: 1) farming experience in Mexico; 2) age; 3) migration experience; and 4) acculturation and education. *Farming experience in Mexico* includes the dichotomous responses to the two questions, “Have you worked on your own or your family’s farm?” (“¿Ha trabajado por su cuenta o en la finca (rancho) de su familia?”); and “Have you worked as a hired farmworker in Mexico?” (“¿Ha trabajado como trabajador agrícola contratado en México, es decir que trabajaba para alguien más?”).

Age had the grouped values of less than 20 years, 20 to 24, 25 to 29, 30 to 34, and 35 and older. *Migration experience* included several variables. Birth region had the values southern Mexico, central Mexico, and northern Mexico: northern Mexico included those states that border on the U.S.; central Mexico included those states south from the border states to the Federal District; and southern Mexico included those states south of the Federal District.¹ Age when first came to the U.S. had the values less than 18, 18 to 24, 25 to 29, 30 to 34, and 35 and older. Number of years worked in U.S. agriculture had the values 1 or 2, 3 or 4, and 5 or more. Moved from place to place for work and H2A visa status² were dichotomous variables. Location of permanent home had the values of Mexico, North Carolina, or other. Return to home village over the winter was a dichotomous measure. Number of months stayed in home village over the winter had values 0 to 3 months, 4 to 6 months, and 7 or more months. Frequency of return to home village had the values of first trip to US, more than once each year, once each year, and less than once each year. *Acculturation and education* included three variables: 1) ability to understand English had the values none, very little, and some; 2) language spoken at home had the values of Spanish or indigenous language; and 3) number of years of school completed had the values of 5 or less, 6, 7 to 9, and 10 or more.

¹The Mexican states in which respondents were born included: 1) for *northern Mexico*, Nuevo León, Sonora, and Tamaulipas; 2) for *central Mexico*—Aguascalientes, Baja California Sur, Durango, Federal District, Guanajuato, Hidalgo, México, Michoacán, Nayarit, Querétaro, San Luis Potosí, Sinaloa, Tlaxcala, and Zacatecas; and 3) for *southern Mexico*—Chiapas, Guerrero, Morelos, Oaxaca, Puebla, Tabasco, and Veracruz.

²An H2A visa allows an individual to enter the United States to work in agriculture for a specified period of time for a particular farmer. The farmer is obligated to provide workers an average of 35 hours of work per week, a specific hourly wage, inspected housing, and to meet all safety requirements, including WPS training.

Analysis included three stages. First, demographic, migration, and acculturation and education characteristics of those farmworker respondents who were born in Mexico were summarized. Second, the agricultural work experience of the Mexican farmworkers in their home country was described, as were the agricultural pesticide use and safety experiences of those with agricultural work experience in Mexico. Finally, cross-tabulations of pesticide use and safety experience variables by selected farmworker characteristics were completed. Mexican farming-experience variables included in the bivariate analysis were worked on own farm and worked as a hired farmworker in Mexico; migration-experience variables included birth region, moved from place to place for work, and H2A visa status; and acculturation and education variables included amount of English understood, language spoken at home, and years of school completed. Chi square tests were used to test the statistical significance of differences in pesticide use and safety experiences in Mexico in terms of the independent variables.

Results

The vast majority of the farmworkers who participated in this survey—277 out of 293 (94.5%)—were born in Mexico. Of the remaining 16 participants, 2 were born in the U.S., 7 in Puerto Rico, 5 in Guatemala, 1 in Honduras, and 1 did not specify place of birth. Because their numbers were so few, survey participants who were not born in Mexico were excluded from further analysis.

The remaining North Carolina farmworkers were more than 90 percent male (Table 1, Column 1). There were many Mexican farmworkers in North Carolina under the age of 18, but since they cannot give legal informed consent, they were not interviewed.³ The interviewed farmworkers ranged in age from 18 to 78 years, with a median age of 27 years. Only 58.8 percent of the Mexican farmworkers were married or living as married. The low percent of married workers resulted from the relatively young ages of these workers (only 27.1% were aged 35 years or older).

Farmworkers in central North Carolina were predominantly from central (54.5%) and southern Mexico (38.6%). While 55.4 percent of these workers came to the U.S. for the first time before the age of 25, a significant number (almost 20%) first arrived in the U.S. at ages greater than 34. Most of these workers had limited experience in U.S. agriculture; 60 percent had worked in U.S. agriculture for only one or two years, and 20.6 percent had 5 or more years of U.S. agricultural work experience. A majority of these workers were truly migrant, with 63.3 percent reporting they move from place to place to work. Almost half the farmworkers in this part of North Carolina came to the U.S. on H2A visas.

These farmworkers had strong ties to Mexico. About 80 percent stated that their permanent home was in Mexico. Four-fifths of these workers returned to their home community in Mexico during the winter, and most remained in Mexico for a period of four to six months.

³All research protocols used in this project were reviewed and approved by the institutional review boards of Wake Forest University School of Medicine and the University of North Carolina at Chapel Hill. Current National Institute of Health regulations state that an individual under the age of 18 cannot give informed consent; therefore, to interview an unemancipated minor requires obtaining informed consent from the minor's legal guardian and informed assent from the minor.

Fewer than 15 percent of the respondents reported not returning to their home community at least once each year.

Most of these workers had little formal education. Thirty percent had fewer than six years (*primaria* in the Mexican system), and 30 percent had completed more than six years. Few reported understanding any English—only 10.5 percent stating that they understood at least some English. A small but significant percentage spoke an indigenous language instead of Spanish at home; these indigenous languages included Tarascan and Nahuatl.

Most (82.7%) farmworkers who came to North Carolina from Mexico had done farm work in Mexico (Table 2). The majority (93.4%) had worked on their own farm, and over a third (34.5%) had worked as a hired farmworker. Comparing columns 1 and 2 of Table 1 indicates that those farmworkers from Mexico with farming experience did not differ from the total group in any significant way. Most of those farmworkers with Mexican farming experience had been involved in Mexican agriculture until quite recently. Half of those who had worked on their own farms did so in the same year they were interviewed in the U.S., and another 23.6 percent had worked on their own farms in the two or three years before the interview. Over a third (35.8%) of the participants who had worked as farmworkers in Mexico had done so in the same year they were interviewed in the U.S., and another 22.2 percent had worked as farmworkers in Mexico in the two or three years before the interview.

Two-thirds of these Mexican farmworkers reported using pesticides in Mexico (Table 3). Fewer than one-third reported having received pesticide safety training in Mexico, and 41.3 percent reported having received any pesticide safety information in Mexico. The sources of pesticide safety training and information were similar, and while respondents could name more than one source, few did so. A dominant source of information (52.2%) and training (30.8%) was the person who sold the pesticides. Employers were sources of safety training and information for about 15 percent of those who have received these, and health care providers were sources for about 10 percent of these workers. Family members and friends were dominant sources of pesticide safety training—over 40 percent of those who received safety training received this training from these informal sources. Family members and friends were the sources of safety information for over 20 percent of those who received safety information.

The great majority (73.8%) of the respondents who had used pesticides in Mexico had used pesticide safety equipment. About three-quarters of those who had used pesticide safety equipment (76 of 107), about half of those who had used pesticides (76 of 151), and about a third of those with Mexican farming experience (76 of 227) had used a mask (*mascarilla*). About the same number that reported using a mask also reported using gloves (*guantes*) and hats (*sombreros*). About half this number (38, 35.5% of safety equipment users) had used goggles (*gafas protectoras*) and suits (*traje protector*).

Farmwork experience in Mexico, having an H2A visa, and speaking an indigenous language at home were each related to differences in pesticide use and safety in Mexico. Working on one's own farm in Mexico did not affect pesticide use or safety. However, those who had done hired farmwork were more likely to have used pesticides in Mexico than those who had

not done hired farmwork (78.2% vs. 60.4%; $p = .007$). Those who had done hired farmwork were more likely to have received pesticide safety training (39.2% vs. 23.5%; $p = .013$) and to have received pesticide safety information in Mexico (57.1% vs. 32.6%; $p = .001$) than those who had not done hired farmwork. Those who had done hired farmwork were more likely to have used safety equipment in Mexico than those who had not done hired farmwork (90.2% vs. 61.9%; $p = .001$). Those with H2A visas were less likely to have received pesticide safety information (22.8% vs. 35.4%, $p = .037$), or to have used pesticide safety equipment in Mexico (65.8% vs. 82.6%, $p = .021$). None of the independent variables had a statistically significant relationship to the specific safety equipment used in Mexico.

Caution is needed in considering the relationship of language spoken at home to pesticide use and safety due to the small number (19) of respondents who spoke an indigenous language. However, those who did not speak Spanish at home were less likely to have used pesticides in Mexico than those who spoke Spanish at home (47.4% vs. 68.3%; $p = .065$). Those who did not speak Spanish at home were less likely to have received pesticide safety training (5.6% vs. 31.1%; $p = .022$) or to have received pesticide safety information (18.8% vs. 43.1%; $p = .057$) in Mexico than those who spoke Spanish at home.

Discussion and Conclusions

These results demonstrate that farmworkers come to the U.S. from Mexico with a variety of experiences with pesticide usage and pesticide safety training. Such experiences—or, in some cases, lack of experience—form the framework within which farmworkers understand the relationship of pesticide usage to human health. Additional research needs to delineate the content of this framework: what do these workers know on their arrival in the U.S., and how does this knowledge affect their beliefs about the efficacy of different pesticide safety methods? The limited research conducted on such beliefs to date is important for health education and intervention development. The analyses of Quandt et al. (1998) and Hunt et al. (1999) have informed the pesticide safety intervention program we have developed (Arcury et al. 2000) for the PACE project. The lack of the concept of pesticide residues and the focus on inhalation rather than transdermal absorption as the primary route of exposure shaped both the content as well as the theoretical framework within which the intervention was developed and implemented (Quandt et al. 2001). Further research on the knowledge and beliefs shaped by prior experience could improve clinical practice and patient education. For example, Baer and Penzell (1993) show how Mexican farmworkers interpreted pesticide poisoning in the framework of a Mexican folk illness (*susto*).

Despite considerable experience in farming and using pesticides, two-thirds of the workers in our sample had received no training or information about pesticide safety. Thus, they are accustomed to regarding pesticides as a common component of farming, not necessarily as a hazardous substance that can produce serious health consequences for themselves or their families. For those who *had* received training or information, the primary sources of pesticide training and information reported were pesticide dealers, the agricultural employer, and family or friends. Pesticide dealers serving as the source of safety information is widespread in developing countries (Andreatta 1998). The obvious conflict of interest between profit and truth about product dangers suggests that reliance on dealers for

information will result in inaccurate information, particularly concerning the health hazards involved. Because pesticides are often repackaged and sold in small quantities, labels that in the U.S. would provide safety information are not available to farmers or, sometimes, to dealers. Because grower training in pesticide safety is not widespread in Mexico (Hunt et al. 1999), neither of the other sources—agricultural employers and family or friends—should be expected to be a reliable source either. Health clinics in Mexico should increase their efforts to provide pesticide safety education to farmers.

There are no comparative data on the proportion of farmers and farmworkers in the United States who receive pesticide safety training. Anyone who wants to be able to buy restricted-use pesticides in the U.S. must participate in a training course and pass a certification test. They must also be recertified every three years, which involves attending a pesticide safety class. However, there are an unknown number of limited-resource farmers⁴ who do not purchase restricted-use pesticides and are not required to receive pesticide safety training. The Environmental Protection Agency (U.S.-EPA 1992) has implemented the Worker Protection Standard (WPS), and this requires safety training. However, our research in North Carolina indicates that only about one-third of farmworkers in this state have ever received training (Arcury et al. 1999b). Larson (2000) has conducted a national evaluation of WPS implementation and found that there are important limitations to its implementation.

This is the first analysis to investigate and report on the migration and occupational background of farmworkers in the U.S. Few studies go beyond asking immigrant workers' nation of origin. Besides shedding light on possible knowledge and beliefs, these data also suggest that studies of pesticide exposure among farmworkers in the U.S. need to attend to the patterns of migration and farming activities while in Mexico. Most North Carolina workers return to Mexico every winter for an average of six months. Many are engaged in farming and using pesticides while there. Thus, most farmworkers have probably been exposed to agricultural pesticides before their arrival. Based on findings such as those by McConnell and Hruska (1993) and Tinoco-Ojanguren and Halperin (1998), they may have biologically measurable effects of this exposure before they arrive in the U.S. This complicates attempts to measure exposure in the U.S. and makes it difficult to assess with biomarkers the effectiveness of pesticide safety training conducted in the U.S. This might not affect analyses using biomarkers for specific organophosphates (these have fairly short half-lives), but would make it extremely difficult to trust results using cholinesterase testing, which reflects more long-term exposure to a broad class of pesticides.

The demographic information from these farmworkers indicates that there is considerable heterogeneity of age and experience. While the sample is predominantly young, the number over 35 who are first-time immigrant workers and the high proportion of workers who are working in U.S. for the first or second year indicates that there are many new and inexperienced workers in the U.S. who require accurate pesticide safety information. In particular, those coming on H2A visas were less likely to have received safety information

⁴The Economic Research Service, U.S. Department of Agriculture (<http://www.ers.usda.gov/whatsnew/issues/safetynet/box.htm>) defines a "limited resource farm" as any small farm with gross sales less than \$100,000, total farm assets less than \$150,000, and total operator household income (from all sources) less than \$20,000. Limited-resource farmers may report farming, a nonfarm occupation, or retirement as their major occupation.

or used safety equipment in Mexico. The proportion of farmworkers with H2A visas was especially high in the region of the state where this research took place, and, thus, it does not represent the U.S. as a whole. However, the North Carolina Growers' Association (NCGA), which administers the largest H2A program in North Carolina, has aggressively developed and marketed its program. The NCGA has now expanded to nearby states. This may result in greater immigration of less experienced farmworkers.

Fewer farmworkers who speak an indigenous language rather than Spanish at home have received pesticide safety training or information, or used pesticide safety equipment in Mexico. As more farmworkers come from Indian populations, there may be a need to increase safety training of these workers in the U.S. The need to produce training materials and hire trainers fluent in these languages is a formidable task.

Future farmworker research must consider the experiences and beliefs that immigrant workers bring with them from their communities of origin. These transnational workers do not come to the U.S. as blank slates. Their experiences and beliefs will influence their work and health behaviors while they work here. Many will arrive in this country already suffering from illnesses and injuries produced by conditions in their places of origin. Learning about the experiences and beliefs these immigrant workers bring with them will help us better direct safety training programs and result in improved lives.

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Characteristics of All Mexican-Born Farmworkers in North Carolina and those Mexican-Born Farmworkers with Farming Experience in Mexico

Table 1.

Respondent Characteristics	All those Born in Mexico		Those with Farming Experience in Mexico	
	N	%	N	%
Demographic				
Gender				
Male	257	92.8	219	95.6
Female	20	7.2	10	4.4
Age in years				
<20	32	11.6	22	9.6
20–24	73	26.4	57	24.9
25–29	62	22.4	51	22.3
30–34	35	12.6	33	14.4
35+	75	27.1	66	28.8
Marital status				
Married/living as married	163	58.8	136	59.4
Not married	114	41.2	84	40.6
Migration				
Region of birth				
Northern Mexico	14	6.9	13	7.4
Central Mexico	131	47.3	110	48.0
Southern Mexico	127	45.8	102	44.5
Age when first came to U.S.				
<18	42	15.2	31	13.5
18–24	114	41.2	91	39.7
25–29	42	15.2	36	15.7
30–34	26	9.4	25	10.9
35+	53	19.1	46	20.1
Years worked in U.S. agriculture				
1–2	168	60.6	132	57.6
3–4	52	18.8	43	18.8
5+	57	20.6	54	23.6

Respondent Characteristics	All those Born in Mexico		Those with Farming Experience in Mexico	
	N	%	N	%
Move from place to place				
No	101	36.7	82	36.1
Yes	174	63.3	145	63.9
H2A visa status				
No	138	49.8	114	49.8
Yes	139	50.2	115	50.2
Permanent home				
North Carolina	49	18.2	36	16.3
Florida	5	1.9	4	1.8
Mexico	215	79.9	181	81.9
Return to home village over the winter				
No	53	19.6	39	17.4
Yes	217	80.4	185	82.6
Number of months you stay in home village				
0–3 months	40	17.7	30	15.6
4–6 months	149	65.9	134	69.8
7 months or longer	37	16.4	28	14.6
How often visit home village				
First year in U.S.	67	25.0	51	22.9
More than once each year	20	7.4	17	7.6
Once per year	143	53.4	123	55.2
Less than once per year	38	14.2	32	14.3
Education/Acculturation				
Level of English comprehension				
None	119	43.0	103	45.0
Very little	129	46.6	101	44.1
Some	29	10.5	25	10.9
Language spoken at home				
Spanish	251	90.6	210	91.7
Indigenous language	26	9.4	19	8.3

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Respondent Characteristics	All those Born in Mexico		Those with Farming Experience in Mexico	
	N	%	N	%
Years of school completed				
5 or less	83	30.0	64	27.9
6	110	39.7	98	42.8
7 to 9	56	20.1	48	21.0
10 or more	28	10.1	19	8.3

Table 2.**Mexican Farming Experience of Mexican-Born Farmworkers in North Carolina**

Farm Work Experience in Mexico	N	%	Total
Did farm work in Mexico			
Yes	229	82.7	
No	48	17.3	277
Worked on own farm (of those with farm work experience)			
Yes	214	93.4	
No	15	6.6	229
Worked as hired farmworker (of those with farm work experience)			
Yes	79	34.5	
No	150	65.5	229
Last time worked on own farm (of those who worked on own farm)			
This year	108	50.0	
In past 2–3 years	51	23.6	
More than 3 years	57	26.4	216
Last time did hired farm work (of those who worked as hired farmworker)			
This year	29	35.8	
In past 2–3 years	18	22.2	
More than 3 years	34	42.0	81

Table 3.

Pesticide Use and Safety in Mexico of Those with Farming Experience in Mexico

Pesticide Use and Safety Training in Mexico	N	%	Total
Used pesticides in Mexico			
Yes	151	66.5	
No	76	33.5	227
Received pesticide safety training in Mexico			
Yes	65	29.0	
No	159	71.0	224
Received pesticide safety training from			
Person who sold pesticides	20	30.8	
Health care provider	7	10.8	
Family member	23	35.4	
Friend	4	6.2	
Employer	10	15.4	
Other	5	7.6	65
Received pesticide safety information in Mexico			
Yes	90	41.3	
No	128	58.7	218
Received pesticide safety information from			
Person who sold pesticides	47	52.2	
Health care provider	8	8.9	
Family member	12	13.3	
Friend	7	7.8	
Employer	12	13.3	
Other	7	7.8	90
Used pesticide safety equipment in Mexico			
Yes	107	73.8	
No	38	26.2	145
Pesticide safety equipment used in Mexico			
Mask	76	71.0	
Goggles	38	35.5	
Gloves	71	72.0	
Hat	80	75.5	
Suit	38	35.8	
Other	17	15.9	107