# The Role of Employers and Supervisors in Promoting Pesticide Safety Behavior Among Florida Farmworkers

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**Background** *Farmworkers in Florida's nursery and fernery industries have an elevated risk of exposure to chemical pesticides due to the enclosed nature of their workplaces and their close contact with pesticide-treated plant material. Farmworkers' beliefs about chemical exposures and their perception of employer's or supervisor's valuing of safety may limit the practice of workplace hygiene.*

**Methods** *Three hundred eighty-two surveys from workers in the nursery and fernery industries in North Central Florida were collected as part of the Together for Agricultural Safety (TAS) Project from 1999–2001. Univariate analyses and multivariate Ordinary Least Squares regression are used to examine the role of individual and structural characteristics on handwashing practices.*

**Results** *Workplace practices such as the provision of written notices of recent pesticide application and the provision of convenient handwashing facilities are important predictors of workplace hygiene. Although farmworker attitudes and beliefs towards the utility of such practices and potential hazards are associated with behavior, they are less significant than the structural variables.*

**Conclusions** *In order for farmworkers to engage in safety behavior that will protect their health, they must be adequately instructed and supported by employers and/or supervisors.* Am. J. Ind. Med. 53:814–824, 2010. *© 2010 Wiley-Liss, Inc.*

*KEY WORDS:* ***farmworkers; pesticides; safety; beliefs; supervisors***

## INTRODUCTION

Floriculture, the production of cut flowers and foliage, potted plants, and bedding plants in greenhouses and fields, is among the fastest growing agricultural segments in the United States. Florida is the second largest producer of floriculture crops, behind California, with $915 million in wholesale value for 2007 [NASS, 2008]. Workers in these industries, like other farmworkers, have a high risk of exposure to chemical pesticides [Lander and Hinke, 1992; Bouchard et al., 2008; Salvatore et al., 2008] and associated occupational illnesses and injuries [Henao, 1998; Methner and Miles, 1998]. In 2006, across the major agricultural states with high levels of floriculture production, 5.59 million pounds of active chemicals were applied, marking a steady increase in the amount of pesticides applied annually. Florida accounted for 27% (1.47 million pounds) of the total pesticides applied in these industries [NASS, 2007].

Because much floriculture production occurs in enclosed environments, farmworkers in these industries are at an increased risk of pesticide exposure. Pesticides applied

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in enclosed environments cannot dissipate as easily as in open fields and farmworkers in floriculture are frequently in close contact with plant material that has pesticide residues [Lander and Hinke, 1992]. Exposure to pesticides can be dermal, oral, and respiratory and can occur through direct contact with pesticides during application, contact with pesticide residue on plants, entry into a recently treated area, or through drift from nearby application [Hoekstra et al., 1996]. Farmworkers' family members may also be exposed to pesticide residues through ''take-home'' exposures [Simcox et al., 1995; Quandt et al., 2004; Rao et al., 2006; Strong et al., 2008]. Take-home exposures occur when pesticide residues on farmworkers' clothing and equipment are brought from the field into residences where, unexposed to the elements, they can persist for a substantial amount of time and present a significant risk for the other household members who come into contact with them [Simcox et al., 1995; Faustman et al., 2000; Lu et al., 2000; Quandt et al., 2004].

Pesticide exposure can result in a wide range of acute health effects including nausea, dizziness, vomiting, headaches, stomach pain, rashes, and eye problems [Ecobichon, 1996; Arcury and Quandt, 2003; Kamel and Hoppin, 2004; McCauley et al., 2006]. There is also strong evidence that suggests that exposure to pesticides can have chronic health effects including respiratory problems, memory disorders, dermatologic conditions, depression [Arcury and Quandt, 2003], cancers such as non-Hodgkins lymphoma [Zahm and Blair, 1993; Blair and Zahm, 1995; Alavanja et al., 2004], and adverse reproductive effects leading to miscarriages and birth defects [Sever et al., 1997; Hanke and Jurewicz, 2004; McCauley et al., 2006]. Children directly exposed to pesticides are at higher risk of developing cancer [O'Leary et al., 1991; Daniels et al., 1997].

Farmworker beliefs about pesticides are key determinants of behavior. Frequent handwashing, use of protective equipment such as gloves and respirators, and removing/washing workclothes after returning home are common safety practices recommended for farmworkers. However, individual beliefs about the effectiveness of these practices can vary based on personal experience, cultural beliefs, and level of education [Quandt et al., 1998]. Other studies suggest that individual health behaviors are determined more by physical and social characteristics such as the provision of safety equipment, the availability of time to practice health behaviors, and the reinforcement of proper safety practices by farmworkers' supervisors [Salvatore et al., 2008].

Federal regulations such as the Environmental Protection Agency's Worker Protection Standard (WPS) [U.S., 1992] and the Occupational Safety and Health Administration's Field Sanitation provisions [U.S., 1987] aim to reduce the risks of illness or injury resulting from farmworkers' occupational exposures to pesticides through the designation of particular workplace behaviors. These regulations require agricultural employers to provide basic safety measures such as information about how to work with pesticides and how to reduce exposure by washing skin and clothing at critical points during the day. The regulations also require employers to provide specific information about pesticides being used at the worksites and access to facilities where farmworkers can wash on a regular and emergency basis. The specific means by which an employer is required to protect farmworkers according to the WPS include: enforcing entry time restrictions into pesticide-treated areas; providing posted and/or oral notice about treated areas to farmworkers; providing information about applied pesticides in a centrally located area; and providing training with specific instructions about how farmworkers can protect themselves from pesticides.

In addition to the WPS, the Field Sanitation provisions of the Occupational Safety and Health Standards for Agriculture [U.S., 1987] require agricultural establishments of 11 or more farmworkers to provide toilet and handwashing facilities (with a basin, container, or outlet with an adequate supply of potable water, soap, and single-use towels) within a one-quarter-mile walking distance of each worker's location in the field. It also requires employers to inform farmworkers about the location of the facilities and the importance of good hygiene practices to minimize exposure to the hazards such as agricultural pesticide residues.

Several evaluative studies have questioned whether these standards have succeeded in protecting farmworkers from pesticide exposure. In particular, the quality and effectiveness of WPS training for farmworkers has been questioned. Researchers have found that employer training may be non-existent, minimal, or in a format that does not guarantee that farmworkers actually learn anything [Arcury et al., 1999; GAO, 2000; Larson, 2000; Arcury et al., 2002]. Absent effective training programs, farmworkers are often left to their own beliefs and experiences in determining what workplace practices are needed to perform their jobs in manners perceived as safe.

A number of studies have found that many farmworkers fail to engage in protective practices even when trained properly [Vaughan, 1993; Arcury et al., 1999; McCauley et al., 2002; Goldman et al., 2004; Strong et al., 2008]. They may not have access to facilities where they can wash their hands during the workday or to washing machines or showers after work. Even if they have access to these facilities, farmworkers may feel too pressured by production demands to take the time necessary to properly follow safety protocols [Arcury et al., 2001a].

Furthermore, several investigations suggest that perceived control over the ability to protect oneself from pesticide exposures is strongly correlated with behavior [Austin et al., 2001; Arcury et al., 2002]. These studies suggest that an individual's perceived vulnerability to health risks and the severity of those health risks are important determinants of safety behaviors, but are limited by perceived barriers and a lack of self-efficacy. In the context of protecting oneself from pesticide exposures, barriers are likely to include the ability to access information regarding health risks. Technical, accurate pesticide safety information is communicated through employers and supervisors, as required by law, thus farmworkers are dependent on these parties for their personal safety [Flocks et al., 2007].

Employer and supervisor attitudes towards the validity and value of pesticide safety practices may breed workplace cultures of indifference that increase the risk of exposure. As the demographic characteristics of farmworker populations change, especially with regards to the increase of younger farmworkers who are less likely to perceive a direct risk due to pesticide exposure [McCauley et al., 2002], understanding how personal beliefs towards pesticides are shaped by and interact with workplace culture becomes essential.

This article examines the relationship between beliefs about pesticide safety and consequent behaviors in the context of two types of floriculture industries in North Central Florida. For purposes of data collection, these industries were characterized as "ferneries" and "nurseries." In Florida, the two settings have somewhat distinct employee populations and workplace risks. Ferneries are fields of fern grown under porous black shadecloth (saran) or under natural tree cover. There is usually a packing shed with toilet and sink somewhere on the property, although it is often not near workers in the field. Temporary toilet facilities are sometimes available closer to workers in field and they may include a washing facility, but these sites are usually poorly maintained. Nurseries involve the production of potted flowers and foliage mainly in structures enclosed by non-porous plastic. These businesses typically have more permanent outbuildings, including some with toilets and sinks.

Because of the enclosed environments, some components of the WPS are stricter for ferneries and nurseries, especially when production occurs within a non-porous structure. For example, the WPS provides for stricter regulations regarding when a farmworker can enter pesticide-treated areas in both ferneries and nurseries and for stricter regulations regarding how farmworkers are notified about pesticide applications in nurseries.

Our analysis begins with an examination of the demographics of nursery and fernery farmworkers and their beliefs regarding the potential hazards of pesticide exposures. We then explore how farmworkers' perceptions of employer and supervisor beliefs regarding safety influence farmworker behavior. Specifically, we focus on worker handwashing—an important behavior that reduces the health risks of pesticide exposure and the likelihood of take-home exposures for farmworker family members. Finally, we conclude with a discussion of how the results may improve health interventions to reduce the adverse health effects of pesticide exposure.

## MATERIALS AND METHODS

The data in this article were collected as part of the Together for Agricultural Safety (TAS) Project. From 1997 to 2003, the TAS project used collaborative principles of community-based participatory research (CBPR) and the methods of social marketing to collect data, then design, implement, and evaluate a health intervention to reduce the adverse health effects of pesticide exposure among Central Florida fernery and nursery farmworkers. The TAS project team included partners from the University of Florida, the University of South Florida, the Farmworker Association of Florida (FWAF), and Best Start Social Marketing, Inc.

CBPR involves an explicit concern for the organizational and community aspects of public health [Israel et al., 1994; Arcury et al., 2001b] and can contribute to the success of health promotion programs [Bracht et al., 1994]. This focus allows the intervention to be culturally viable and sustainable. Some of the principles from the CBPR literature that the TAS project implemented include: building on the strengths and resources within the community; facilitating collaborative partnerships in all phases of research; using an iterative process of data collection, review, analysis and additional data collection; and dissemination of project findings gained to all partners [Israel et al., 1998; Flocks et al., 2001]. This process created a strong partnership between TAS researchers, community advocates and marketing experts, and ultimately, the design of a comprehensive educational intervention for farmworkers, supervisors, and employers.

The TAS project used a social marketing approach to guide research, data analysis, and intervention development activities. Social marketing applies commercial marketing technologies to program development activities in order to influence behavior in a personal and socially beneficial way [Andreasen, 1995]. Combining CBPR with social marketing requires that community members are actively involved in all phases of the research, analysis, intervention development, and evaluation processes.

During the first 3 years of the project, the TAS project team completed extensive formative research to guide project activities. Formative research is essential in social marketing projects to understand the consumers' behavior, to segment and choose target populations, and to develop marketing plans that result in products [Bryant et al., 2000]. The TAS formative research activities included participant observation by academic researchers at worksites, 16 focus groups with Hispanic and Haitian farmworkers, 14 healthcare provider interviews, 25 supervisor/employer interviews, and 382 farmworker surveys.

Data from the focus groups were used to guide the development of the questions for the farmworker survey instrument. An analysis team of four academic and community-based partners studied focus group transcripts and made a list of farmworkers' recommendations for reducing pesticide-related health problems. Each analysis team partner then independently reviewed this list and summarized the pros and cons of each recommendation while considering factors such as current policies; access to equipment, clothing or other resources needed; consequences, costs and benefits of taking the recommended action; costs and benefits of continuing the current behavior; perceived ability and risks of taking the recommended action; whether the burden of behavioral change was equally distributed among workplace parties—employers, supervisors and farmworkers; and whether there were already multiple efforts in the area. Targeted behaviors that the team felt were feasible to change were: handwashing practices, clothes-washing practices and the observance of re-entry regulations. A planning model was drafted and distributed to the entire TAS project team for review and comment. There was general agreement about the most important themes in the findings, particularly the importance and feasibility of improving handwashing at the worksite, given the above listed factors.

A small workgroup drafted the first survey instrument and distributed it to the larger group for review and comment. This process was repeated until the group felt it had an instrument sufficient for pretesting. The survey instrument focused on health behaviors and outcomes related to potential exposure to pesticides. The surveys included questions regarding farmworker and family health problems, current preventative behaviors and attitudes toward occupational hazards. The Institutional Review Board (IRB) at the University of Florida reviewed and approved the human subjects protocols for this study. In accordance with IRB requirements, all survey respondents were administered and signed informed consent forms.

The draft survey instrument was translated into Spanish and Haitian Creole and interviewers pretested it among approximately 16 Haitian nursery farmworkers and 12 Hispanic nursery and fernery farmworkers. Pretest interviewers were instructed to focus on the mechanics of the questions, for example, whether the wording, meaning, and coverage of relevant issues were adequate. Interviewers reported the results of the pretests to the team that was developing the survey.

Interviewers were recruited from the FWAF and from target communities. They participated in a 1-day training conducted by TAS project members from the University of Florida and Best Start Social Marketing to educate them about the project and the surveying goals, how to administer informed consent and surveys, how to track attempted and completed interviews (formal tracking sheets were created to account for all subject attempts), and how to document subject responses. Interviewers practiced in teams and completed some interviews in teams of two. Senior staff observed new interviewers to assure appropriate survey practice and documentation.

Three hundred eighty-two farmworker surveys were conducted from 1999 to 2001. At the time, no sampling frame for Florida nursery and fernery farmworkers existed. Thus, TAS project partners initiated an enumeration process for farmworker residences across five counties where the majority of ferneries and nurseries exist. The processes for enumerating Hispanic farmworkers and Haitian farmworkers differed. Hispanic farmworkers were selected through the targeted sampling of 13 communities, where TAS partners created maps of farmworker households through visual identification. This process resulted in the location of more than 1,000 households, from which respondents were randomly selected by the proportion of residents in each of the 13 communities. Because the Haitian nursery farmworker community is more dispersed in Central Florida, respondents were enumerated through snowball sampling. Although this process is potentially less representative, the population of Haitian nursery farmworkers is relatively small and the TAS project partners believed it possible to locate and survey the complete population in this manner.

Respondents were asked approximately 82 questions regarding potential occupational pesticide exposure, beliefs regarding safety, behaviors on the job, and general demographics. The central variables for this analysis were beliefs about pesticides and safety behaviors. The variables included in the analysis that measure farmworker beliefs about pesticides include three scales. The first scale asked respondents to estimate their exposure to pesticides. Respondents were asked "how often do pesticides fall or drift onto your body while working" and presented options ranging from everyday to never. A second dichotomous variable asked respondents whether washing hands after working with plants reduced exposures to pesticides. The third and final variable to gauge beliefs about pesticides asked respondents whether or not they believed pesticides caused some past sickness while at work.

The second central variable, as well as the dependent variable in the ordinal least squares regression, is a scaled measure of handwashing behavior. The handwashing scale is based on four consecutive questionnaire items which asked the respondent to assess the frequency of their handwashing activities. This series of questions asked "how often do you wash your hands at work before . . . eating something, drinking something, going to the bathroom, and leaving for home." A fifth question asked about handwashing prior to smoking or chewing gum and tobacco. Smoking was not included in the handwashing scale since only 60% of the sample smoked. Respondents were given Likert scale options of choosing always, most of the time, sometimes, and never. The generalized handwashing scale was standardized so that a score of four represented always washing one's hands in each of the four categories and zero for never. The scale mean was 3.21, with a standard deviation of 0.81. Cronbach's alpha for the indexed handwashing behavior was 0.71.

In addition to the belief and behavior variables, the analysis presented below also includes measures of workplace safety characteristics. These measures draw on the respondents' perceptions of their workplaces, not on actual data on each nursery or fernery that a respondent may have worked at. However, given the focus on the relationship between beliefs and behaviors, relying on the perceptions of workplace characteristics is logical. We include four measures to assess the variability in workplaces. First, we include an estimate of the size of the nursery or fernery based on the respondent's estimate of how many farmworkers were employed there. Second, we include three measures of pesticide safety including the frequency of written warnings provided to farmworkers prior to entering a field recently sprayed with pesticides, verbal warnings of the same nature, and the provision of pesticide safety training programs. Finally, we include a subjective measure of whether the respondent believed their immediate supervisor perceived handwashing to be important following contact with plants, ferns, or trees. This measure is included to gauge the priority to which pesticide training and the provision of handwashing locations are given at various workplaces.

All surveys were entered using the data entry software, Questionnaire Programming Language. Results were analyzed using the SPSS statistical analysis software. Univariate and multivariate analyses of the survey data were completed to determine key variables that predict handwashing practices among fernery and nursery farmworkers.

## RESULTS

Survey respondents in the nursery industry included farmworkers of Haitian and Mexican descent, while those in the fernery industry were only of Mexican descent. This reflects the general demographics of farmworkers in these industries (see Table I) which is likely due to chain migration patterns in the towns and counties where the industries are located. The Mexican farmworkers in the ferneries tend to be significantly younger and more likely to be male than their nursery counterparts. Nursery farmworkers were significantly more likely to be female. Although most of the Mexican farmworkers in the ferneries were under the age of 30, some of the older farmworkers have more years of experience in the industry than the nursery farmworkers. In terms of family status, both nursery and fernery farmworkers are more likely to be living with a spouse or partner and on average, tend to have children present in their households. The fernery farmworkers, however, were more likely to have children present in the household with nearly two-thirds of the farmworkers participating in this survey reporting having children at home.

**TABLE I.** Farmworker Survey Demographics

| Worker characteristic | Fernery workers | Nursery workers |
|---|---|---|
| Ethnicity | | |
| Haitian | 0.0 (0) | 0.35 (81) |
| Mexican | 0.99 (149) | 0.56 (130) |
| Other | 0.01 (2) | 0.09 (20) |
| Age | | |
| 18–29 years | 0.54 (68) | 0.27 (62) |
| 30–49 years | 0.36 (46) | 0.57 (129) |
| 50–69 years | 0.10 (13) | 0.16 (36) |
| Female | 0.45 (68) | 0.66 (152) |
| Married/cohabiting | 0.76 (115) | 0.71 (164) |
| Children in home | 0.65 (98) | 0.50 (116) |
| Years in industry | | |
| 0–5 years | 0.40 (60) | 0.54 (121) |
| 6–10 years | 0.30 (45) | 0.27 (60) |
| >11 years | 0.30 (44) | 0.19 (42) |
| Total | 151 | 231 |

Only 8% of all respondents reported no perceived exposure to chemical pesticides while at work. These data show that for fernery farmworkers, all respondents perceived they had some type of exposure to pesticides; 92% of nursery farmworkers also perceived they had been exposed (Fig. 1). Fernery farmworkers reported significantly higher frequencies of exposure than nursery farmworkers, particularly in the regular cutting and handling of plants (28%) and working after chemicals had been applied (26%). For nursery farmworkers, exposure occurs primarily through working after chemicals have been applied (20%), the regular cutting and handling of plants (12%), and touching wet plants (8%).

Farmworkers from both industries reported a variety of significant health problems they believed were associated

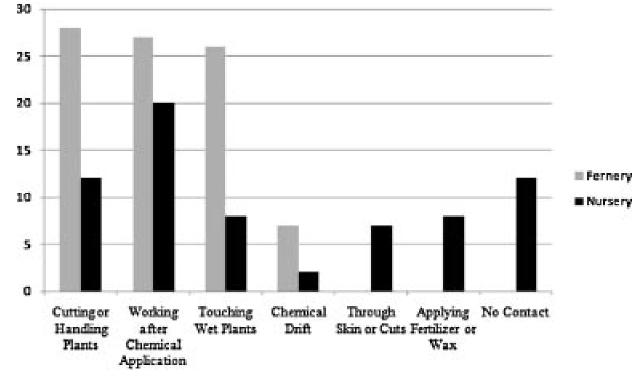


**FIGURE 1.** Farmworker reported routes of exposures to pesticides.

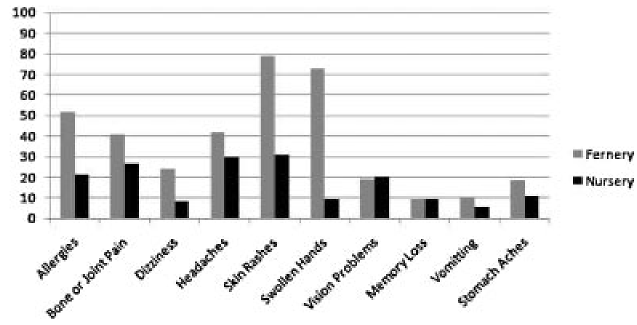


**FIGURE 2.** Percentage of farmworkers reporting health problems.

with exposure to pesticides (Fig. 2). Respondents were asked to select from a list of symptoms associated with agricultural pesticide exposure and 61.5% reported experiencing some type of symptom. Nearly 80% of fernery farmworkers reported experiencing skin rashes and 75% of fernery farmworkers also reported experiencing swollen hands. Overall, nursery farmworkers were significantly less likely to report experiencing health problems believed to be caused by pesticide exposure, though a fair amount (30%) of nursery farmworkers reported experiencing headaches, rashes, and joint pain.

The total number of perceived pesticide-related health problems is also greater among fernery farmworkers (Table II). 58.1% of fernery farmworkers reported three or more health problems they attribute to pesticide exposure, compared to 23.5% of nursery farmworkers. The mean number of symptoms reported by all farmworkers was 2.37. At the other end of the spectrum, only 11.8% of fernery farmworkers reported that they experienced no symptoms while roughly half of the nursery population believed their health to be detrimentally affected by exposures to occupational pesticides.

Farmworkers can protect themselves from the adverse health effects of exposures through knowledge and preventative practices. However, this information must typically be obtained at the workplace from employers and supervisors. Table III presents data regarding farmworkers' perceptions about their workplaces and the attitudes of employers and supervisors regarding pesticides. In general, there was no difference in the size of the companies employing fernery and nursery farmworkers. A majority of the farmworkers surveyed worked for an employer with more than 20 employees. The greatest difference between fernery and nursery operations is the frequency with which both written and verbal pesticide warnings are given to employees before they enter areas after pesticides have been applied. Fernery farmworkers were significantly more likely to have never received both verbal and written warnings after pesticides were applied, while nursery farmworkers were significantly more likely to receive warnings most of the time or always before entering a recently sprayed area. Correspondingly, nursery farmworkers were also much more likely to report that their supervisors believed handwashing was important after coming into contact with plants, ferns, or trees. In addition to receiving warnings regarding pesticides more frequently and perceiving that employers valued handwashing, nursery farmworkers were also significantly more like to receive pesticide safety training translated into their native language.

One of the most important aspects of pesticide safety training relevant to the farmworker population sampled for this research project is proper handwashing behavior. Handwashing is a function of both personal behavior and availability of adequate water supply, soap, and towels. Respondents reported varied accessibility to satisfactory water for handwashing. While more than 90% of nursery

**TABLE II.** Total Number of Symptoms Related to Pesticide Exposures

| | Fernery (%) | Nursery (%) | All farmworkers (%) |
|---|---|---|---|
| 0 | 11.8 | 46.8 | 33.2 |
| 1–2 | 30.1 | 28.7 | 29.3 |
| 3–4 | 25.0 | 12.5 | 17.3 |
| 5–7 | 24.3 | 9.3 | 15.1 |
| 8+ | 8.8 | 1.7 | 5.1 |

**TABLE III.** Workplace Characteristics

| | Fernery farmworkers | | Nursery farmworkers | |
|---|---|---|---|---|
| **Workplace characteristic** | **n** | **%** | **n** | **%** |
| Company size | | | | |
| 1–20 | 69 | 46.6 | 82 | 46.7 |
| 20+ | 79 | 53.4 | 93 | 53.3 |
| Verbal pesticide warnings | | | | |
| Never | 46 | 31.8*** | 25 | 11.8 |
| Sometimes | 25 | 16.6 | 22 | 10.4 |
| Most of the time | 1 | 0.7 | 28 | 13.3*** |
| Always | 77 | 51.0 | 136 | 64.5** |
| Written pesticide warnings | | | | |
| Never | 37 | 25.0*** | 21 | 9.6 |
| Sometimes | 19 | 12.8* | 12 | 5.5 |
| Most of the time | 0 | 0.0 | 29 | 13.2*** |
| Always | 92 | 62.2 | 157 | 71.7* |
| Boss believes handwashing is important | 73 | 54.1 | 141 | 92.8*** |
| Pesticide safety training provided | 103 | 69.6 | 173 | 74.9 |
| Pesticide safety training translated | 12 | 29.3 | 99 | 62.7*** |
| Total population | 151 | — | 231 | — |

Significant $t$-test of independent means; $^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$.

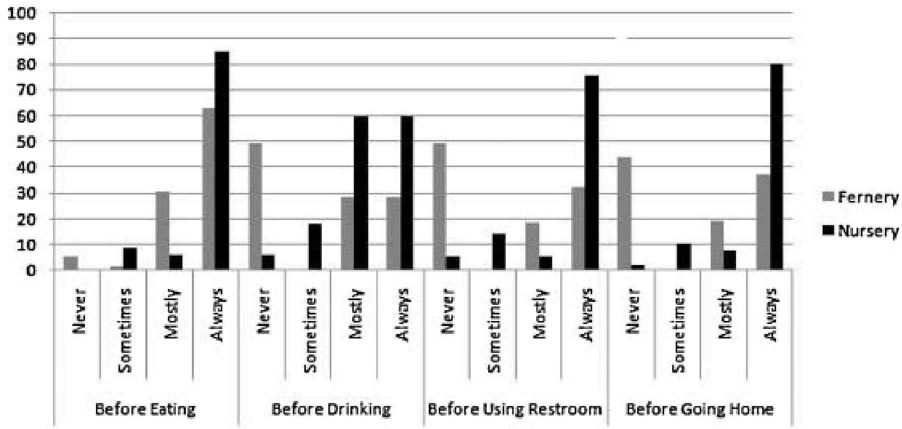


**FIGURE 3.** Percentage of farmworkers reporting frequency of handwashing behaviors.

farmworkers and 85% of fernery farmworkers reported access to bathrooms within 5 min of their location at work, far fewer (33% and 77% respectively) reported access to clean water at these bathrooms. Figure 3 presents comparative data on a variety of specific handwashing behaviors by fernery or nursery employment. Farmworkers are very likely to always wash their hands prior to eating something at work (62.8% of fernery farmworkers and 85% of nursery farmworkers). However, they were much less likely to report always washing their hands prior to drinking. Only 28.7% of fernery farmworkers reported always washing their hands prior to drinking, where 59.6% of nursery farmworkers practice this behavior—a significant decline from the 85% always washing their hands prior to eating. Perhaps more disturbing is the trend among fernery farmworkers to report never washing their hands prior to using the restroom (49.3%) and prior to going home (43.9%). These reports of never washing hands among fernery farmworkers are statistically significantly different than nursery farmworkers, who report always washing their hands prior to using the restroom or going home with significantly higher frequencies (75.4% and 79.9%, respectively). Handwashing before using the restroom is an important safety behavior to reduce potential exposure from pesticide contaminated hands with sensitive areas of the body and handwashing before going home can reduce take-home exposure that can contaminate other household members.

Handwashing behavior among farmworkers is correlated with both workplace characteristics and individual beliefs regarding the hazards associated with pesticide exposures. The strongest correlation to handwashing behavior comes from the characteristics of the workplace, with nursery workplaces and workplaces where farmworkers perceive their supervisor believing handwashing is important receiving Pearson's r scores of 0.50, which is significant at the 0.01 level (2-tailed test). All other Pearson's r scores for correlation with handwashing were 0.30 or less. Among the demographic, individual beliefs, and workplace characteristic values, only one measure of correlation was found higher than a 0.30, which suggests statistically significant but weak relationships within the independent variables. The correlation within the independent variables, with a Pearson's r of −0.41, was found between Mexican ethnicity and nurseries. Given the fact that Mexican workers make up 99% of all fernery farmworkers (see Table I), this result is not surprising. However, the strength of this correlation is at only 0.41 and therefore does not fully explain the variation in handwashing behavior. A multiple regression model better predicts the frequency of handwashing behavior among farmworkers.

The results of the multivariate analysis suggest that the frequency of handwashing is largely a function of workplace characteristics. This multivariate OLS regression predicts a scale of regular handwashing behavior. Tests for multicollinearity in the regression model reveal no significant problems with correlation between multiple independent variables.[1] Model 1, which examines the relationships between the individual demographic characteristics of farmworkers, suggests that farmworkers who are of Mexican descent, male, and of the youngest age category are significantly less likely to regularly wash their hands. Model 2 introduces individual beliefs about the hazards of pesticide exposure. The only belief to be significantly correlated with handwashing behavior is the self-reported frequency of exposure to pesticide drift; where the relationship between a higher frequency of self-reported exposure is negatively correlated to frequent handwashing behavior. This finding would suggest that those farmworkers who reported higher levels of exposure to pesticide drift in the fields are less likely

[1] Variance inflation factors (VIF) were calculated for each independent variable. The highest VIF was 3.25 for Mexican ethnicity. A VIF greater than 10 is the most common indicator of multicollinearity. The condition index for the full model was 24.1, which is below the standard threshold of 30 [Belsley et al., 1980].

to regularly wash their hands. The significance of ethnicity, gender, and age remain unchanged with the introduction of the belief variables (Table IV).

However, with the introduction of the workplace variables in Model 3—the strongest model with an $r^2$ of 0.52, the significance of both the demographic characteristics and belief variables dissipates. By controlling for variation in workplace characteristics, neither ethnicity nor gender remains significant. The only demographic characteristic significantly correlated with handwashing in Model 3 is work experience, where having less than 5 years experience is negatively correlated with handwashing behavior. The most significant variables to be correlated with handwashing behavior in Model 3 are whether or not a farmworker works at a nursery and whether written warnings are provided prior to entering an area where pesticides had been recently applied. Several other workplace characteristics are also significant predictors of handwashing behavior, including company size—where larger businesses are negatively associated with regular handwashing. Also significant in Model 3 is the perception that a farmworker's boss (which could be an employer or a supervisor) thinks handwashing is important, where a farmworker is more likely to wash their hands if their boss thinks it is important to do so. When controlling for workplace characteristics, one of the belief variables becomes significant, though in the unexpected direction. In Model 3, the belief that pesticides are responsible for causing sickness is negatively correlated with handwashing behavior, suggesting that those farmworkers who strongly believe that pesticides are responsible for their individual illnesses are less likely to wash their hands than those who do not believe pesticides are harmful to health. Nonetheless, the results of the multivariate analysis suggest that the strongest predictors of frequent handwashing behaviors are characteristics of the workplace, and in particular the presence of written warnings at areas where pesticides have recently been applied.

## DISCUSSION

Handwashing at agricultural worksites is an important means of protecting farmworkers against pesticide exposure. At certain critical times of the workday; such as before eating, drinking, smoking, using the toilet and leaving for home; handwashing diminishes the risk of farmworkers contaminating or recontaminating themselves and others with pesticide residues that persist on their skin. While other

**TABLE IV.** Multivariate Analysis

| | Model 1 B (SE) | Model 2 B (SE) | Model 3 B (SE) |
|---|---|---|---|
| Demographics | | | |
| Ethnicity | | | |
| Mexican | −0.49*** (0.2) | −0.44*** (0.12) | 0.00 (0.04) |
| Gender | | | |
| Female | 0.32*** (0.09) | 0.22*** (0.1) | 0.04 (0.03) |
| Age | | | |
| 18−29 | −0.23** (0.1) | −0.22* (0.11) | −0.04 (0.03) |
| Children in household | −0.12 (0.09) | −0.14 (0.11) | −0.01 (0.03) |
| Married | −0.012 (0.01) | −0.03 (0.03) | −0.02 (0.03) |
| Work experience | 0.07 (0.09) | −0.01 (0.1) | −0.06* (0.03) |
| <5 years | | | |
| Beliefs about pesticides | | | |
| Regularly exposed to pesticides | — | −0.15** (0.06) | −0.01 (0.02) |
| Washing hands reduces exposure | — | 0.17 (0.12) | −0.01 (0.03) |
| Pesticides caused past sickness | — | −0.433 (0.12) | −0.08* (0.04) |
| Workplace characteristics | | | |
| Nursery | — | — | 0.14*** (0.05) |
| Company employees 20+ | — | — | −0.02* (0.03) |
| Verbal pesticide warnings | — | — | 0.01 (0.01) |
| Written pesticide warnings | — | — | 0.05*** (0.01) |
| Boss believes handwashing is important | — | — | 0.06* (0.04) |
| Pesticide trainings provided | — | — | 0.035 (0.04) |
| Constant | 3.63*** (0.2) | 4.17*** (0.27) | 0.59*** (0.09) |
| $r^2$ | 0.14 | 0.29 | 0.52 |
| df | 6 | 9 | 15 |

safety behaviors are also important, the TAS project focused on handwashing as a behavior that potentially reveals general workplace safety in terms of whether there is access to appropriate facilities and support for the farmworkers. The costs and benefits of handwashing can be addressed through health intervention. The burden of handwashing is spread across workplace parties and does not fall solely on the farmworker. Employers and supervisors must do their part to encourage farmworkers and provide time and facilities and farmworkers must follow recommendations. Furthermore, handwashing at agricultural workplaces has already been recognized as a safety behavior critical enough to be recommended by federal regulations.

Although other researchers have suggested that farmworker safety behavior can be linked to individual farmworker and cultural beliefs, the TAS findings, taken together, emphasize the importance of employer/supervisor participation in supporting and encouraging farmworkers' safety behavior by providing the appropriate facilities and types of warnings. All of the workplace measures are positively associated with handwashing. This is much more positively associated with handwashing than the belief measures. The full model is the most robust model, meaning the inclusion of workplace characteristics improves the overall accuracy of the multiple regression models. These findings reinforce the responsibility placed on employers by the regulations such as the EPA Worker Protection Standard and the OSHA Field Sanitation provisions and indicate that the starting place for workplace safety lies with the employer.

The fact that certain components of the WPS are stricter for the types of industries represented in this study may help explain some of the findings. The regulation requires that both posted and written notice be given to farmworkers about areas that have been recently treated with pesticides in industries where worksites are enclosed by non-porous material, such as the nurseries in the TAS study. This stricter regulation may account for the finding that nursery farmworkers were significantly more likely to receive warnings most of the time or always before entering a recently sprayed area than fernery farmworkers. It may also explain the significance of employment in a nursery and posted notification as predictors of handwashing behavior.

However, the stricter WPS requirements do not explain why nursery farmworkers were much more likely to report that their bosses perceived handwashing to be important or why nursery farmworkers were also significantly more like to receive pesticide safety training translated into their native language. It may be that nursery farmworkers correlate the frequency of warnings they received from their employer or supervisor with a heightened sense of concern. Whatever the reason for the farmworkers perception, the significance of the perception is the finding that farmworkers are more likely to engage in safety behavior such as handwashing if they perceive their supervisor is supportive.

The tone of the WPS sections regarding provision of safety information and training indicates that employers and their representatives must be proactive and specific in instructing all farmworkers regarding the dangers of pesticide exposure. These regulations mandate that posted information and training cover health-related topics such as the ways in which pesticides can enter a farmworker's body, and the potential adverse effects of exposure as well as specific ways in which farmworkers can protect themselves, such as washing before eating, drinking, using chewing gum or tobacco, using the toilet, and after returning home. Furthermore, the regulations require that employers provide the physical means—water, soap, and towels—for routine and emergency washing at the worksite. The TAS findings suggest that this proactive behavior by employers and supervisors may be enough to override any personal tendency on the part of farmworkers to avoid handwashing.

## CONCLUSIONS

Based on TAS data, the project team designed a health intervention to improve handwashing behavior at worksites. The intervention targeted four different groups: farmworkers and their families, employers, supervisors, and healthcare providers. It included the construction and distribution of portable handwashing tanks to be placed at worksites near farmworkers and an educational campaign that went beyond the requirements of the WPS. The educational campaign included posters in Spanish and Haitian Creole to be displayed at worksites and health clinics; a *fotonovela* in Spanish about the importance of handwashing; and informational packets for employers and supervisors. In keeping with CBPR principles, the handwashing tank and all educational materials were designed with direct input from farmworkers, employers, and supervisors. The portable handwashing station was pretested, then pilot-tested and evaluated in two nurseries and three ferneries with the result that the frequency of handwashing increased in all locations.

The TAS farmworker survey that informed the intervention and that is described in this article had some limitations and these are common to CBPR projects and health behavior surveys. The time and labor needed to collaboratively develop the survey instrument, train interviewers, and administer the survey were intensive. Academic researchers are sometimes concerned about the reliability of community-based research, thus quality control is integral to the process. The expectations and demands of academic institutions differ from community-based organizations, thus goals of individual academic and community researchers also differ. However, in the end, the outcomes of the CBPR experience seemingly outweigh the limitations: partners with diverse skills are joined together to address a common task, research data can be more relevant and applicable, research data are enhanced by local knowledge, community partners receive valuable training in research methods that they can continue to use, and the academic/community relationship can result in future research and funding opportunities.

Another limitation of the TAS farmworker survey was that it measured only self-reported behavior with limited objective verification from the brief times researchers were able to conduct participant observation in the fields. However, as the goal of the eventual health intervention was to change particular safety attitudes and reduce the barriers to behavior change, self-reported behavior was an adequate indicator of daily activity at the job site. Because of the social desirability of reporting handwashing to interviewers reported behaviors may even have been slightly exaggerated.

Finally, the TAS farmworker survey was administered to workers in specialized industries in one state and may not be representative of other U.S. farmworker populations. Fernery and nursery worksites are different environments than open fields. Farmworkers in these industries are employed in tasks that may not resemble tasks in other agricultural industries. However, the TAS survey findings generally confirm what other researchers have found. In order for farmworkers to engage in safety behavior that will protect their health, they must be adequately instructed and supported by employers and supervisors. They must be provided with proper facilities to remove pesticides from their skin at critical points of the day. Training about pesticide exposure must be reinforced on a regular basis through reminders from supervisors that work the closest with them. All these criteria are already required by federal regulations. The TAS survey data show that, as anticipated by these regulations, employer and supervisor attitudes are critical starting places for farmworker safety.

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