J Immigrant Minority Health (2013) 15:975–981
DOI 10.1007/s10903-012-9685-4

ORIGINAL PAPER

Engaging Latino Farmworkers in the Development of Symbols to Improve Pesticide Safety and Health Education and Risk Communication

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Published online: 26 July 2012

Abstract The working and living environments of farmworkers put them and their families at risk for pesticide exposure and, consequently, immediate and long-term health effects. In this study, visual materials for a pesticide toxicology safety and health curriculum were constructed by engaging farmworkers in various stages of symbol development. Twenty-seven farmworkers in two states participated in this descriptive case study through focused small group discussions and interviews. Our findings support the importance of vivid and realistic symbols, the effectiveness of a traffic-light symbol in communicating technical information to farmworkers, and the need to engage low-literacy end-users in the production of educational materials. This work informs the development of curricula for other vulnerable populations pertaining to a variety of health-related topics, as well as discussions surrounding regulatory proposals to revise the United States Worker Protection Standard.

Keywords Pesticides · Health education · Farmworkers · Toxicology

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Background

Farmworkers, who provide hand labor to cultivate and harvest crops, are vulnerable to pesticide exposure because they typically work and live in close proximity to agricultural chemicals [1]. Farmworkers encounter pesticide residues on plants and crops or in the soil while conducting normal crop maintenance and harvesting activities [2] and, less frequently, during pesticide application through drift from adjacent fields or treatment of fields where farmworkers are working [2]. Farmworkers may introduce pesticides to their homes and families by transporting residues via clothing, skin, shoes, and vehicles [3, 4].

According to the most recent National Agricultural Workers Survey [5], the majority of hired farm laborers in the United States are foreign-born and Spanish-speaking, with 75 % born in Mexico and 2 % in Central America. Among foreign-born workers, 90 % are male, and the average age is 32 years. Most workers have completed no more than 7 years of formal education. Studies of Hispanic adult learners indicate that literacy scores in Spanish are limited, although literacy levels are higher in Spanish than in English [6]. The majority of foreign-born farmworkers neither speak nor read English [5].

Studies have found an association between pesticide exposure and short-term and long-term health effects [1, 7]. Signs of acute poisoning range from mild symptoms, including headaches and dizziness, to more severe effects, such as convulsions and respiratory distress. In the Agricultural Health Study, pesticide applicators in Iowa and North Carolina have been found to have a higher incidence of specific cancers such as prostate cancer and multiple myeloma [8], neurological effects such as depression and Parkinson's Disease [9, 10], and reproductive effects such as menstrual cycle influences [11].

Literature on farmworker understanding of pesticide concepts raises concerns about the extent of farmworker knowledge of immediate and long-term consequences of agricultural chemical exposure [12, 13], although variability exists in reported farmworker understanding of basic pesticide safety information [14]. Farmworker education literature has emphasized the need for recognizing farmworkers' lay knowledge while increasing their basic technical understanding of pesticides, particularly identifying names, properties, and potential adverse health effects of pesticides [15].

Cognitive psychology identifies presentation of information using both visual and verbal modes to enhance learning [16]. Drawing upon Baddeley's model of working memory [17], instruction reduces cognitive load and promotes learning when it engages both the articulatory loop that processes verbal information and the visual-spatial sketch pad that processes spatial information. The use of symbols in instruction of farmworkers provides visual-spatial stimulation.

Recently, a study commissioned by the United States Environmental Protection Agency investigated approaches to communicating pesticide safety and health information to farmworkers [18]. Farmworkers indicated a preference for materials containing fewer words, more symbols, and greater use of color. Glasnapp et al. [18] found that traffic-light colors had meaning for Latino farmworkers in conveying the concept of different levels but did not apply this finding to communication of specific pesticide concepts. Recent work by Rother [19] indicated that South African farmworkers did not understand pesticide label pictograms as technically intended. The author concluded there was a need to move away from top-down illustration design, stressing the importance of involving the end-user in developing materials for pesticide risk and health communication. The present study reflects efforts to create new materials to address these gaps.

A *Pesticides and Farmworker Health Toolkit* [20] was developed with Rother's [19] suggestions in mind, involving farmworkers in the development of curricular materials. The present study investigates farmworker perceptions of curriculum symbols throughout symbol development. Symbols of people and objects familiar to farmworkers and reflective of their everyday lives were created to increase participants' pesticide knowledge [15].

Methods

This descriptive case study engaged 27 Latino farmworkers in *focused small group discussions* [21] and follow-up interviews to inform the development and assessment of symbols designed for a new curriculum named the *Pesticides and Farmworker Health Toolkit*. Four focused small group discussions and three individual interviews with farmworkers were conducted in two highly agricultural southeastern states with large migrant populations. The authors' university institutional review board granted administrative approval for this study.

Participants

Criteria for participation in the study included the following: (1) current employment in crop field work, (2) Hispanic/Latino ethnicity or country of origin as Mexico or Central American country, (3) Spanish for first language, and (4) age of 18 years or older. Outreach and service provider colleagues recruited study participants representative of the farmworker population in the study states.

The 27 farmworkers who participated were largely representative of the national farmworker population [5]. The average age of participants was approximately 32 years. Twenty-five farmworkers indicated Mexico as their home country. Approximately 10 % of participants were female. The majority of participants had completed no more than 7 years of formal education, with the '4–7 years' category as the mode. Participants varied greatly by experience working in agriculture in the United States (ranging from 3 months to 20 years) and seasons cultivating the specific crop (ranging from <1 complete season to 16 seasons). Documentation status (e.g., undocumented, H-2A visa for temporary agricultural work) was not collected for the protection of participants. Nearly all participants indicated that they worked with multiple crops over the course of a growing season (e.g., tobacco then sweet potatoes and perhaps later Christmas trees).

Data Collection

Focused small group discussions, as put forth by Cristancho et al. [21], were the primary means of data collection. Cristancho et al. [21] advocate this methodology for use with rural Latino immigrants because of its informal recruitment approach and less rigid data collection structure. Groups consisted of 3–8 farmworkers. A native Spanish speaker familiar with the farmworker population and pesticide safety concepts moderated all discussions in Spanish, following a general framework for questioning.

Stage 1: Development of Materials

Using limited prior research on farmworker learning and symbols, primarily Glasnapp et al. [18] and the authors' experiences, the authors developed a series of symbols with a medical illustrator and a graphic designer. Symbols developed for the curriculum represented farmworkers'

experiencing common symptoms of pesticide illness (9 symbols), plants at various stages of growth (4 symbols), and a traffic light. Drawings of individuals' experiencing symptoms of pesticide illness were developed to help farmworkers recognize and respond to emergency situations. Illustrations of crops at different stages of growth were created to organize the most commonly used pesticides into meaningful categories relevant to the work environment and to indicate the most hazardous phases of crop production based on chemical use. The traffic light was designed to communicate the toxicological concept of relative toxicity.

Stage 2: Feedback on Original Materials

Two focused small group discussions with male farmworkers ($n = 7$, 8) were held in collaboration with a community health center and grassroots farmworker coalition, respectively. Discussions took place at the health center and coalition facilities, locations deemed nonthreatening to the farmworker participants. These initial discussions involved showing farmworkers visual educational materials and gathering feedback. Open-ended questions asked by the facilitator included: What do you think the main point is? What are you being asked to do? What does this symbol mean to you? What is happening in these pictures? What part do you find unclear or confusing? What would make it more attractive?

Findings from Stage 2 dictated revisions to the symbols. The authors provided farmworker criticisms and suggestions to the medical illustrator for incorporation into the revised symbols.

Stage 3: Feedback on Revised Materials

A *Pesticides and Farmworker Health Toolkit* lesson was delivered to a group of male farmworkers ($n = 9$) by clinic outreach workers to assess the utility of the symbols in curriculum materials. A focused small group discussion with these farmworkers was conducted following the lesson to ascertain the workers' preferences and understanding of health concepts. Open-ended questions about the symbols, as well as about the lesson in its totality, were asked by the facilitator in the clinic facility.

An all-female focused small group discussion ($n = 3$) was held in a second state in collaboration with a local migrant association. Farmworkers were shown symbols from the curriculum and asked open-ended questions. Single-gender discussions aligned with Cristancho et al.'s [21] methodology for focused small group discussions. Separating men and women allowed for greater participant comfort and openness and reflected the established practice of selecting focus group participants with similar attributes [22].

Approximately 1 month after the initial small group discussions, follow-up interviews were conducted with three farmworkers to *member check* discussion findings to confirm that the researchers' impressions were appropriate [23]. The farmworkers assessed the materials that had been revised as a result of previous feedback. Follow-up interviews were held at the migrant camps where farmworkers lived. The same set of open-ended questions was asked of individual farmworkers regarding the revised symbols.

Data Analysis

Digital audio recordings were made of all focused small group discussions and interviews. Audio files were transcribed in Spanish and then translated into English by a third party, yielding approximately 150 single-spaced pages of transcription data. The content of the transcriptions was analyzed by identifying prevalent themes within and across discussions. In addition to member checks with discussion participants via follow-up interviews, member checks between the facilitator and researchers took place within 24 h of focused small group discussions to compare impressions of recorded observations [23].

Results

The centrality of symbols in communicating health concepts to this low-literacy population was highlighted by the comments of a female farmworker:

> We see what the people in the illustrations are doing. Because there are people that do not know how to read. Maybe right now we know how to read and I have learned a little here … because to be honest when I left school I was in first grade, and I didn't know how to read. … When I couldn't read that well before, I would only look at the pictures. So, I think that for people who do not know how to read the illustrations grab more of our attention.

Importance of Vivid and Realistic Symbols

Data analysis revealed that vivid and realistic symbols were important for farmworkers to understand and engage with curriculum materials.

Farmworkers' Initial Perceptions (Stage 2): Inadequacy of Tobacco Plant Symbols

The case of the tobacco plant crop stage symbols highlights farmworker confusion over cartoon-like symbols and their preference for life-like symbols (see Table 1 for participant

comments). Transcriptions contained farmworker criticisms of the two-color, less realistic symbols of tobacco [24]. The problematic nature of these less realistic drawings was brought to light during a discussion in which farmworkers could not differentiate between the topping and suckering and harvest phases. Without being able to identify the crop stage symbols, the farmworkers had difficulty understanding when certain pesticides were likely to be used and, therefore, when they were most likely to be exposed. In detailing how the plant develops and how the illustrations should represent that development, the farmworkers expressed the importance of capturing in the image the way that they experience the crop in the field. Initial feedback informed revisions to symbols. Farmworkers requested very specific changes, such as adding "soil, roots, bigger leaves at the bottom, and small leaves on the top like it has just started to grow" for the transplant image.

Farmworkers' Reaction to Revisions (Stage 3): Life-Like Symbols Facilitate Understanding

In follow-up interviews in which revised symbols were shown, farmworkers praised the more realistic symbols (see Table 1). With the revised symbols, farmworkers were able to associate the illustrations with their daily activities. Highly realistic symbols of crops, therefore, were found to be more useful in communicating the chemicals used during specific production stages.

Symptoms Capture Most Attention

In all discussions and interviews, farmworkers described the symptom illustrations as being most effective in capturing their interest in the educational materials (see Fig. 1). The farmworkers accurately identified the initial graphic and life-like symptom illustrations designed to communicate abdominal pain, vomiting, throat irritation, skin irritation, headache, eye irritation, dizziness, and diarrhea. In Stage 2, farmworkers did not recommend specific revisions to the symptom illustrations, as they had with the crop illustrations. As a result, Stage 3 symptom illustrations were not modified.

These realistic symbols also engaged farmworkers in the lesson, as demonstrated by their interjection of anecdotes after viewing the symbols. For example, responding to the illustration for eye irritation, one farmworker shared her experiences: "[W]hen they are spraying pesticides, and one enters the area, and we cannot say anything because it's an order they [supervisors] receive too and that pesticide can get in your eyes. Then your eyes get red." Another worker described how he can identify with the illustrations of farmworkers' experiencing symptoms:

> Yes, we are the ones risking our lives there all the time. And sometimes it does happen that one of us gets dizzy. For example, the chemicals don't make me vomit or cause me any nausea or anything like that. What I do get is excessive sweating and if for example, we start cutting, let's say from 3 pm then when I get home, I am feeling very weak not wanting to talk or be bothered. Sometimes I feel my hands shaking. Some other people get dizzy or vomit or they even get diarrhea or a rash, just like it is shown here.

Understanding Relative Toxicity Through Traffic-Light Symbol

In Stages 2 and 3, farmworkers demonstrated an understanding of the use of traffic-light colors to represent different levels of toxicity presented by pesticides (see Fig. 2). Because farmworker feedback indicated a clear understanding of the traffic light, no revisions were made to the symbol between stages. Using their knowledge of this everyday symbol, farmworkers comprehended the toxicological principle of relative toxicity: "In my opinion, I think that every color in there is a symbol. Every color is a different symbol that means toxic, less toxic, or more toxic." Transcriptions revealed that farmworkers identified the most and least toxic pesticides used in a particular crop and crop stage using the traffic-light concept. Higher toxicity levels were most readily recognized by farmworkers: "Suppose the red color means the most toxic, the most dangerous. The one in the middle, the yellow, would be not so dangerous."

Discussion

This case study sought to develop symbols that would effectively communicate pesticide safety and related health concepts to farmworkers, who are vulnerable to pesticide exposure because of hazardous working and living environments [1]. Our findings highlight the importance of highly realistic plant and symptom symbols in the curriculum and the utility of the traffic light to communicate relative levels of pesticide toxicity. These symbols engaged low-literacy farmworkers from the study group in pesticide safety materials.

In developing specific symbols for a pesticide health and safety curriculum for farmworkers, this study advances the work by Glasnapp et al. [18], who found that farmworkers preferred more symbols and vivid illustrations in hazard communication. Farmworker participation in this research addresses Rother's [19] call for farmworkers' input in developing symbols for pesticide safety and reflects the practice of engaging Latino audiences in material development seen in other educational interventions [25].

Table 1 Comparison of symbols and corresponding comments and findings for original and revised tobacco crop stages

	Transplants	Field control	Topping and suckering	Harvest	Participant comments	Findings
Original	1 	2 	3 	4 	"The thing is, the way the [original] drawing is there, it looks like you just put three leaves together, but if you want to do it correctly, you would need to … show the plant from the beginning." (1) "It doesn't look like it has any kind of roots." (1) "But here [in the image for topping and suckering when the flowers are removed from the tobacco plant] the flower doesn't look right. It looks like it is just a stick without flowers. And in fact they even stay like that when the flowers dry out: that's how it looks." (3) "[The image] looks like they had cut off the tobacco and they had just put it all together on a stick." (3)	Appear oversimplified and cartoon-like Lack sufficient detail (i.e., soils, roots, leaves at various stages of growth) Fail to communicate clearly distinct stages
Revised	5 	6 	7 	8 	"In fact, they [the crop symbols] all are better now. The pictures are much better and easier to understand." (5–8) "[The plant] looks just like that in the field." (5–8) "Here it looks like the plant is approximately on its second harvest; once the leaves are more yellow, it would be the third cutting of the flower." (8)	Resemble the crop in the field Convey specific phases of crop development and production Prompt workers to associate images with particular work tasks

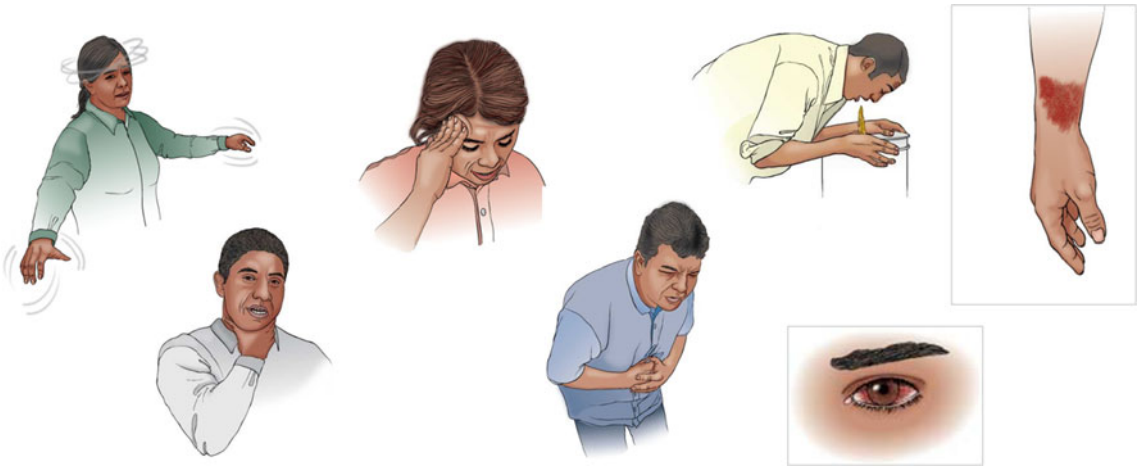

Fig. 1 Illustrations of farmworkers' experiencing pesticide poisoning symptoms

Fig. 2 Traffic light and associated toxicity signal words to communicate relative toxicity. Danger/Peligro = *Red*, Warning/Aviso = *Yellow*, Caution/Precaución = *Green*

Initial farmworker feedback and suggested revisions to tobacco crop stage symbols revealed the extent to which symbols should be life-like to communicate intended health messages to this population with low literacy levels and limited formal education. Although the original symbols appeared sufficiently realistic to the authors, who are literate and familiar with agricultural production practices, the farmworkers, who interact with plants on a daily basis, found these symbols unclear, confusing, and problematic. Because the individuals who develop health curricula are typically highly literate, involving individuals with limited reading and writing abilities in the development of curricula for low-literacy populations is critical to ensure successful communication. The methodology described here provides a useful model for developers of health education materials for the engagement of low-literacy and immigrant populations in the design of visual curricular components.

The focused small group discussions with farmworkers also demonstrated the value of utilizing symbols of familiar objects and settings as a way to recognize farmworker expertise and personalize curricular concepts. The specificity with which farmworkers critiqued original illustrations, particularly of crop stage symbols, and their interjection of anecdotes reflected their engagement with the materials.

Findings from this study will inform further development of learning materials for the *Pesticides and Farmworker Health Toolkit* [20; visit the study website for additional information about these educational materials: http://go.ncsu.edu/pesticide-toolkit]. Traffic-light and symptom symbols described here will be used in future *Toolkit* materials, and the methods used in the development of tobacco plant symbols will be applied to 10 other crop commodities for expansion of the *Toolkit* series to reflect hand labor-intensive production in the southeastern United States. Additionally, the symptom symbols developed through this study may have relevance beyond farmworker pesticide education and occupational health to include a variety of health-related topics and curricula. Future work will assess quantitative increases in farmworker knowledge as a result of utilizing symbols developed in this study. Potential limitations to the current study include the lack of assessment data related to farmworker learning and a narrow focus on tobacco as the prototype agricultural commodity for the *Toolkit* series.

This work has implications for informal and regulatory occupational and environmental health policy. For instance, employers may voluntarily apply the traffic-light color coding described here to their pesticide inventories, and manufacturers may incorporate the color coding into the design of pesticide labels. Though this study is limited by a small sample size and the subjective nature of qualitative research, it has the potential to inform discussions surrounding regulatory proposals to revise the United States Worker Protection Standard [26] relative to hazard communication by identifying specific symbols tested with farmworkers who are demographically representative of the national farmworker population. This study provides a model for implementation of several recommendations for Worker Protection Standard improvements made by the General Training Issues Workgroup and detailed in the

National Assessment of the Worker Protection Program, including the development of standard training materials with culturally relevant graphics [27].

In the long term, as found by Burke et al. [28] in a meta-analysis of relative effectiveness of safety and health training methods, use of effective and engaging pesticide safety education materials will reduce pesticide exposure and illness in the susceptible farmworker population and empower workers with basic pesticide toxicology knowledge necessary to ask meaningful questions and make informed decisions.

Acknowledgments We thank Brenda Bunch, medical illustrator, for her illustrations of crop stages and symptoms of pesticide illness. We also thank the farmworkers and collaborating organizations for their time in making this study possible. This study was funded by the Pesticide Environmental Trust Fund of the North Carolina Department of Agriculture and Consumer Services. We thank our Project Officer, Kay Harris, for her assistance throughout the study.

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