Effectiveness of Interventions to Reduce Pesticide Exposure in Agriculture

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Abstract

The harmful effects of acute pesticide poisoning have been well documented as an established hazard of agricultural work, while the evidence of the association between chronic pesticide exposure and health consequences, continues to emerge. Despite many pesticides have been banned or restricted in several developed countries, exposures to these toxic agents are still occurring in most of the developing world. The objective of this review is to determine the effectiveness of educational interventions designed to reduce exposure to pesticides in order to prevent health effects in agricultural workers. Intervention approaches to prevent pesticide exposure in agriculture vary vastly from country to country probably depending on the level of development achieved. Although many of the papers on educational safety interventions reported some positive results, the availability of randomized controlled trials for this topic is limited and several interventions exclusively measured changes in attitudes or knowledge of participants, with scarce efforts to determine if there was a consistent reduction in pesticide exposure. We conclude that although educational interventions show some efficacy at raising participants’ awareness of pesticide risks, studies using better quality educational approaches are needed.

Keyword: Pesticide exposure, Educational interventions, Preventive measures, Agricultural workers.

1. Introduction

The harmful effects of acute pesticide poisoning have been well documented as an established hazard of agricultural work, while the evidence of the association between chronic pesticide exposure and health consequences, continues to emerge. Despite many pesticides have been banned or restricted in several developed countries, exposures to these toxic agents are still occurring in most of the developing world [1, 2].

In the last decades concern has been raised about the long-term effects of pesticides on human health [3, 4]. In addition to acute poisonings, there is a wide range of diseases that have been suggested to be related to chronic exposure to pesticide, including cancer, neurobehavioural disorders, impaired immunity, endocrine problems and reproductive disorders [3, 5]. Pesticides may be categorized according to their function (e.g. insecticides, herbicides, fungicides), or their chemical structures (e.g., organochlorines, organophosphates, carbamates, phenoxy acids) [3, 4]. The main routes of absorption of pesticides into the body are dermal, oral, and inhalation. Skin exposure route largely prevails for workers in agriculture.

However, relatively little is known about the awareness and health beliefs of workers who are exposed to pesticides and how to develop preventive interventions that effectively reduce the long-term effects of these hazardous substances.

An increasing number of studies conducted in the last two decades among agricultural workers found that reducing exposure to pesticides is possible not only through environmental control measures but especially by emphasizing and encouraging the use of personal protective equipment (PPE) and education and training of workers in correct preventive behaviours. Arcury, et al. [6] studied how safety information affects the perceived pesticide safety risk and control among farmworkers and how perceived risk and control affects farmworkers knowledge and safety behaviour [6]. They found that receiving information about pesticide safety (e.g. warning signs) reduced perceived risk and increased control.
Cross-sectional studies on the degree of adherence to correct safety behaviours by agricultural workers show that safety precautions are often scarce [7]. McCauley, et al. [8], studying 166 agricultural workers in Oregon (USA), found that only 18% used some type of protective clothing, while 75% went home with their work clothes, with 33% changing these clothes > 30 min after arriving home [8]. In a group of 383 female farm workers in Washington State, Thompson, et al. [9] reported that 46% did not remove their boots before entering their home after work, and 45% did not remove their work clothes within 1 h of returning home [9].

Even less attention has been paid to the safety behaviours of vulnerable working populations such as pregnant women, who might have a higher risk than the rest of the population for adverse pregnancy outcomes and reduction in fertility [5].

In the study of Goldman, et al. [10] in California, a substantial proportion of pregnant women living in farm households were not adopting pesticide safety behaviours [10].

A study from Italy found that pregnant greenhouse workers performing the most dangerous jobs often did so without using PPE [11]. Even the use of gloves was absent in 50% of pregnant greenhouse workers who during their pregnancy prepared and mixed pesticides, and among 38% of those who applied pesticides directly.

Intervention approaches to prevent pesticide exposure in agricultural workers vary vastly from country to country probably depending on the level of development achieved. Studies on practices indicate that unsafe use of pesticides is common in developing countries. Insufficient legislation combined to illiteracy, poverty and unfavourable weather conditions result in higher health risks from occupational exposure [12]. In the more industrialized countries, pesticide safety practices often depends on workers’ perceived susceptibility, educational level and safety training, rather than on legal regulations or economic conditions [7]. Educational campaigns such as those undertaken in the USA in the 1990s have shown that pesticide safety practices can improve by appropriate educational interventions [13, 14].

The objective of this review is to determine the effectiveness of educational interventions designed to reduce exposure to pesticides in order to prevent health effects in agricultural workers.

2. Methods
2.1. Search Strategy

2.2. Study Population
We evaluated studies that addressed pesticide exposure or poisoning of subjects of all ages and both genders. Subjects could be agricultural workers of all ages and both genders, all persons that are professionally involved in agricultural activities associated with pesticides (i.e. mixers, loaders, sprayers; general farm workers).

2.3. Types of Intervention
Educational interventions applied to reduce pesticide exposure were included. Such interventions may apply to the national, regional, organizational, community or individual level. Example interventions considered included conducting worker education and training programs aimed at demonstrating the proper use of personal protective equipment (PPE), enhancing safety behaviours such as hand washing after pesticide application and frequent changes of work clothes, increasing the knowledge and awareness of pesticide-associated health risks, improvement of pesticide application and mixing methods, passing new pesticide laws and regulations, and using incentive interventions. Behaviour changes will be evaluated both by self-reported questionnaires and structured questionnaire administered by trained interviewers.

2.4. Inclusion Criteria
This review includes all randomized controlled interventions (RCI), pretest/post-test interventions (PPI), controlled pretest/post-test interventions (cPPI), and time series designs (TSD) irrespective of language of publication. Studies that examined the effectiveness of an educational intervention targeted at agricultural working populations were selected. Studies with educational programs targeted at non-working populations (eg., families, children and households) were excluded by the present analysis. Studies were included according to the terminology previously adopted in studies evaluating the effectiveness of an educational program or a policy intervention in which X stands for the intervention that is being evaluated (e.g., training campaigns, introduction of PPE, graphic warning labels through pesticide legislation), and “O” stands for an observation (e.g., enhanced adherence to pesticide safety behaviours, improved KAP score for safe pesticide handling) [2] (Tab.1). For randomized controlled interventions, there should be mentioned that participants are randomly (R) assigned to the intervention and control group (Tab. 1).

For PPI comparison of outcomes from study participants before and after an intervention is introduced (Tab.1). cPPI is a follow-up study of participants who have received an intervention and those who have not, measuring the
outcome variable both at baseline and after the intervention period, comparing either final values if the groups are comparable at baseline, or change scores (Tab. 1). TSD resemble the pretest/post-test designs, with the exception that there are multiple measurements before and/or after the intervention.

2.5. Types of Outcomes
The primary outcomes of interest were grouped into the following categories:

1) effectiveness of an educational program promoting PPE use (e.g. gloves, breathing mask and boots, eye protection) and proper safety behaviours (e.g. frequent changes and washing of work clothes and other personal hygiene).

2) knowledge acquisition and awareness (through pre-and post-tests administered in participants), knowledge attitude and practice (KAP) questionnaires or structured tests evaluating acquisition among workers of negative health effects of pesticides will be assessed.

3. Results
A total of 29 studies were identified that described an educational intervention for the prevention of pesticide risks; 8 of these met our inclusion criteria [15-22]. The remainder were excluded because did not include a specific education intervention to reduce pesticide exposure (n=7), or were mainly targeted to farmworkers’ families (n = 9), or were previous systematic reviews (n=2). The characteristics of the included studies are shown in Table 1. All were pre-intervention and post-intervention studies, with the exception of two studies that were randomized trials using concurrent controls [21, 22]. Control groups were often only defined as individuals in which exposure was measured in the absence of the intervention; and the number of study subjects generally were quite small. Two studies used non-randomized pre-intervention and postintervention design but also had concurrent controls [15-22]. Five studies were conducted in the United States [15, 16, 21, 22]; the remainder were conducted in Colombia [18], India [19], and Thailand [20]. The duration of each intervention was highly variable, ranging from a 60 min course to sustained interventions lasting up to 6 months.

3.1. Pretest/Post-Test Studies
Most of the evaluations of educational programs utilized a pretest/post-test design to examine changes in self-reported behaviours, attitudes or knowledge, or some combination of the three. Only the PPI study conducted by Vela Acosta, et al. [15] had concurrent controls [15]. This study was a 60 min pesticide program providing training about sources of pesticides and pesticide absorption and toxicity among 152 migrant farmworkers in Colorado [15]. The intervention trial group (n=77) demonstrated significantly better posttest scores than the control group (n=75) with improvements in farmworkers' pesticide safety knowledge (p<0.001) and increased perceptions of pesticide-related risks (p<0.001) [15]. One pretest/post-test study examined an intervention using Spanish one-act plays to increase Washington farmworkers’ (n=185) knowledge about pesticide safety and other health issues. The intervention was found to be effective in increasing farmworkers’ knowledge about pesticides (p<0.01) [17]. Similar significant increase in knowledge were found among intervention studies conducted in Colombia, India, and Thailand [18-20].

3.2. Randomized Controlled Interventions
Only two of the educational interventions analyzed have a randomized controlled design, finding that educational interventions had significant effects on the use of PPE, in particular gloves, during the most recent application. In particular, Salvatore, et al. [21] conducted a cluster-randomized controlled trial among 130 farmworkers from Monterey County CA, with a significant improvement found in the use of gloves (OR: 5.0; 95 % CI 1.7-14.8), and wearing clean work clothes (OR: 3.4; CI 1.2-9.0) after the intervention. [21]. Similarly, the randomized control trial conducted by Perry and Layde [22] among approximately 100 randomly assigned Wisconsin dairy farmers observed a significant change after the educational sessions in the use of gloves (OR: 1.23; 95 % CI 1.13-1.34) and any other gear (OR: 1.53; 95 % CI 1.05-2.11), and a significant reduction in the total number of pesticides used (OR: 2.04; 95 % CI 1.52-2.75) [17].

3.3. Effectiveness of Knowledge Acquisition and Awareness
Several studies addressed the effectiveness of knowledge acquisition and awareness using knowledge and practice (KAP) questionnaires or structured tests evaluating acquisition among workers of negative health effects of pesticides. The use of KAP questionnaires was common in developing countries with perhaps limited resources to undertake more refined quality interventions. A participative strategy-based occupational health and labour risk educational intervention was conducted among 659 potato farmers from the Boyacá department of Colombia [18]. This study evaluated the impact of educational intervention concerning knowledge, attitudes and practices (KAP) aimed at changing behaviour in pesticide use, finding significant changes in KAP (p < 0.001) [17]. A further educational intervention using a KAP questionnaire was provided by Sam, et al. [19] among 74 pesticide handlers from Karnataka state, South India in order to evaluate the effectiveness of educational interventions [19]. The average baseline KAP score improved after education significantly at first follow-up (P < 0.001) [20]. Finally, a training pesticide program conducted over a six-month period by Janhong, et al. [20] found that the average baseline KAP score improved after education significantly at first follow-up (P < 0.001) [19].

3.4. Effectiveness of Educational Programs Promoting Proper Safety Behaviours
Four studies included in the review examined the effectiveness of an educational program promoting the use of some form of personal protective equipment (e.g. gloves, breathing mask and boots, eye protection) and proper safety behaviours (e.g. frequent changes and washing of work clothes and other personal hygiene) [15, 16, 21, 22].
All the studies reported some positive changes in outcomes following the interventions with significant improvement in the use of gloves observed in three studies [16, 21, 22]. Two of the four studies utilized a RCI methodology to examine changes in self-reported behaviours [21, 22]. The remainder non-randomized trial studies used a pre-post test methodology with concurrent controls [15, 16]. In particular, the intervention trial conducted by Vela Acosta, et al. [15] demonstrated also improvements in readiness to change for washing hand in the field (OR: 3.84; 95 % CI 1.3 - 10.9) and for separating clothes before washing them (OR: 1.3; 95 % CI 1.0 - 1.5) [15, Salvatore, et al. [21] found a similar significant improvement in washing hands before going home (OR: 3.5; 95 % CI 1.2-10.0) after the intervention [21]. All the educational interventions promoting proper safety behaviours were conducted in US countries which provided comprehensive occupational health services.

4. Conclusions

Our review shows that a variety of educational approaches have been studied for the prevention of pesticide-related risks. We found that the systematic application of educational interventions can promote pesticide safety. However, it is difficult to determine which particular educational intervention is the most effective because the studies used a variety of strategies, many in combination with other approaches to prevent pesticide risks. We found that studies of educational interventions conducted in lesser developed countries, with perhaps fewer resources to implement technological advances in pesticide control, also found similar considerable benefit, as did studies that were undertaken in more industrialized countries. Although most of the interventions addressed and emphasized the need for proper use of PPE, unfortunately compliance with PPE use remains inadequate [15-22].

The availability of RCI is limited for the present topic. This may be due to the fact that the interventions designed to reduce pesticide exposure are often different from the experimental interventions in other work settings and require greater availability of financial resources. The two RCIs showed that the intervention had significant effects on use of PPE, in particular gloves, during the most recent application [21, 22]. Proper adherence to PPE is particularly important as skin exposure route largely prevails for workers in agriculture and previous studies have reported negative health outcomes (e.g. haematological and other diseases) deriving from prolonged hand contact to toxicants or the misuse of gloves in several workplaces [23-25].

The findings of these studies suggest that it is possible to have at least a short-term effect on pesticide application practices and pesticide safety behavior by increasing safety knowledge, intentions, and health risk perceptions. Although many of the papers on educational safety interventions reported some positive results, they were very heterogeneous, and we were unable to determine which type of educational intervention has the best potential to reduce pesticide risks. Several interventions were good at raising participants’ awareness of pesticide risks and exclusively measured changes in attitude and knowledge, or intended behavior change with scarce efforts to determine if there was a consistent reduction in pesticide exposure.

In conclusion, we find that although educational interventions show efficacy at raising awareness of pesticide risks, studies using better quality educational approaches under carefully controlled conditions are needed. We recommend the use of randomized trials to study educational interventions. For nonrandomized interventions, we suggest the use of a time-series design with multiple observations before and after intervention and use of a parallel control group.

References


Table 1. Effectiveness of Interventions to Reduce Pesticide Exposures. Characteristics and results of the included studies (O = observational; R = randomized; N = without randomization; X = intervention; RCI = randomized controlled intervention; PPI = participatory-practice intervention; TDE = time to death effect).

<table>
<thead>
<tr>
<th>Reference</th>
<th>Design</th>
<th>Methodology</th>
<th>Intervention</th>
<th>Participants</th>
<th>Outcomes</th>
<th>Results</th>
<th>Notes</th>
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<tbody>
<tr>
<td>Mandel et al., 2002</td>
<td>RCI, N</td>
<td>R, O, X</td>
<td>Four weekly/field-based educational sessions to increase awareness of pesticide exposure, promote safe behavior at work and at home</td>
<td>315 farmers/employed at Monterey County, CA, strawberry farms</td>
<td>Impact of educational intervention on knowledge, attitude and practice (KAP) at 1 year post-intervention</td>
<td>Significant improvements in the use of gloves (OR: 2.9; 95% CI 1.7-4.8), wearing proper work clothes (OR: 5.4; 95% CI 1.2-22.5) and washing hands before and after pesticide use (OR: 3.5, 95% CI 1.2-10.3)</td>
<td>Absence of improvement in some hand-handling behaviors</td>
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<tr>
<td>Janhong et al., 2005</td>
<td>PPI, X</td>
<td>O, X, O</td>
<td>A participative strategy-based occupational health and safety intervention</td>
<td>658 private farmers from the Boyanup department of Western Australia</td>
<td>Impact of educational intervention on awareness of pesticide exposure, promote safe behavior at work and at home</td>
<td>Significant improvements in the use of protective clothing (OR: 1.2; 95% CI 1.0-1.5)</td>
<td>Educational intervention in valuable, low cost intervention to promote change in hand-handling behaviors</td>
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<tr>
<td>Sam et al., 2009</td>
<td>RCI, N</td>
<td>O, X, O</td>
<td>An intervention using a knowledge-attitude-behavior (KAB) approach</td>
<td>130 farmworkers from Colombia</td>
<td>Increase in farmworker's pesticide knowledge, safety risk perception, and safety behavior outcomes</td>
<td>Significant changes in KAP (p &lt; 0.001)</td>
<td>Educational intervention in valuable, low cost intervention to promote change in hand-handling behaviors</td>
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<td>Sun et al., 2004</td>
<td>TSD</td>
<td>O, X, O</td>
<td>Education was provided through a structured individual educational training program</td>
<td>784 farmers from rural areas, South Korea</td>
<td>Effectiveness of educational intervention on knowledge, attitude, practice (KAP) at 1 year post-intervention</td>
<td>The average baseline KAP score improved after the educational intervention significantly at follow-up (P &lt; 0.001)</td>
<td>Significant decrease (P &lt; 0.001) was also seen in the knowledge from the first to the second KAP assessment, which may be attributed to a decrease in retention of knowledge due to the time interval between the follow-ups</td>
</tr>
<tr>
<td>Nils-Acosta et al., 2005</td>
<td>PPI, X</td>
<td>O, X, O</td>
<td>A 6-month program provided training about the mixture of pesticides and pesticide absorption and toxicity. A post-test was administered to all participants prior to the pesticide program. Within 2 weeks of the post the experimental group used the pesticides; and approximately 1 month later a post-test was administered to all participants.</td>
<td>314 migrant farmers in Colorado assigned to either the experimental (n=157) or the control group (n=157)</td>
<td>Pesticide knowledge, safety risk perception, and safety behavior outcomes</td>
<td>Increase in farmworkers' pesticide knowledge (p &lt; 0.001), safety risk perception (p &lt; 0.001), and readiness to change for washing hand in the field (OR: 3.9; 95% CI 1.0-10.3) and for changing clothes before washing hands (OR: 1.3, 95% CI 1.0-1.6)</td>
<td>The majority of study population does not believe that they can influence their own health through their own actions, but that such actions are beyond their control in the hands of doctors and others and that the population that the training seemed to be least effective</td>
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<tr>
<td>Jangbong et al., 2005</td>
<td>PPI, O</td>
<td>O, X, O</td>
<td>A training pesticide program conducted over a six-month period</td>
<td>314 farmers from Rachaburi Province, Thailand</td>
<td>Effectiveness of educational intervention on knowledge, attitude, practice (KAP) at 1 year post-intervention</td>
<td>The average baseline KAP score improved after the educational intervention significantly at follow-up (P &lt; 0.001)</td>
<td>Small field tests involving few workers</td>
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<tr>
<td>Elkind et al., 2002</td>
<td>PPI, N</td>
<td>O, X, O</td>
<td>An intervention using a knowledge-attitude-behavior (KAB) approach</td>
<td>185 Washington farmworkers</td>
<td>Pesticide knowledge, safety risk perception, and safety behavior outcomes</td>
<td>Increase in farmworkers' knowledge about pesticides (p &lt; 0.001)</td>
<td>Self-selected and self-reporting sample with indirect measures of attitude and behavior</td>
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<td>Petty et al., 2004</td>
<td>RCI, N</td>
<td>R, G, X</td>
<td>Three four-hour sessions with approximately 100 randomly assigned participants</td>
<td>66 Wisconsin dairy farmers randomly assigned to pesticide use or control procedures</td>
<td>Changes in end use of protective equipment, personal protective equipment, and self-reported dermal exposure</td>
<td>Significant changes in the use of gloves (OR: 1.2; 95% CI 1.1-1.3) and any other gear (OR: 1.3; 95% CI 1.2-1.5); significant reduction in the number of bottles used (OR: 2.0; 95% CI 1.2-3.5);</td>
<td>No significant impact on achieving full PPE compliance, no reduction in the amount of self-reported pesticide exposure during the most recent application reported by applicators</td>
</tr>
<tr>
<td>Mandel et al., 2002</td>
<td>PPI, X</td>
<td>O, X, O</td>
<td>Multiple pesticide intervention to farm households, educational programs on pesticides for country schools, and community education</td>
<td>508 Nitrate farm workers and 555 (184 in the intervention and 372 in the control group)</td>
<td>A change in use of gloves and other protective clothing while handling pesticides. Moderate improvement in use of gloves and other protective clothing while handling pesticides. Use of gloves relative change rate was 2.2 (OR: 1.2-3.1); for those 50% risk protection was use in 3.1 (OR: 0.4-11.3), while those 50% of risk pesticide intervention use in 1.4 (OR: 0.4-11.3);</td>
<td>The majority of study population does not believe that they can influence their own health through their own actions, but that such actions are beyond their control in the hands of doctors and others and that the population that the training seemed to be least effective.</td>
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