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Effectiveness of educational interventions to promote safe handling of pesticides: protocol for a systematic review and meta-analysis

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ABSTRACT

Introduction Appropriate use of pesticides minimises harm to human health and the environment. Despite regulations and restrictions on use, however, many farmers still use highly toxic pesticides in ways that endanger their health and the environment. Many pesticide users know little about the health effects of these chemicals or how to handle them safely. A systematic review will collate evidence of the effectiveness of educational interventions among farmers regarding health hazards and the safe handling of pesticides. The review aims to summarise the impact of educational interventions on knowledge and reported behaviour of pesticide users and to identify characteristics of more effective interventions.

Methods and analysis We will search MEDLINE, LILACS, AGRICOLA, IMBIOMED, SciELO, Web of Science, Scopus, Embase databases and from the grey literature, Open Grey and WHO to identify potentially eligible studies. We will consider randomised and non-randomised controlled trials that evaluated the impact of educational interventions among farmers about the safe use of pesticides. We will include studies published between 2000 and 2024 in English, Spanish and Portuguese and consider outcomes of knowledge about pesticide health effects, knowledge about safe handling of pesticides and reported behaviour when handling pesticides. A meta-analysis of eligible studies, using a random-effects model, will estimate the impact of educational interventions on the outcomes as the difference between the intervention group and the control group at the last point of measurement. We will assess heterogeneity using the χ^2 test and I^2 statistic, conduct a sensitivity analysis by removing each study from the meta-analysis and evaluate publication bias with a funnel plot and Begg and Egger tests. Subgroup analyses will examine the impact of different kinds of educational interventions.

Ethics and dissemination Ethics approval is not required as no information from individuals are collected. The results will be published in a peer-reviewed journal or disseminated at relevant conferences.

PROSPERO registration number CRD42023413028.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This systematic review incorporates studies not included in previous reviews and recent studies evaluating the effects of educational interventions on the knowledge and behaviour of pesticide users.
⇒ We will use Covidence software to classify studies and eliminate duplicates. A further search using the Search Rabbit application will help us identify studies that have not been previously reported.
⇒ The small number of studies, heterogeneity of intervention duration and variation in interventions may prevent the quantitative synthesis of effects on all outcomes of interest.

INTRODUCTION

Pesticides negatively impact human health and the environment. The United Nations estimated that 200 000 people, most of them in developing countries, die each year due to the use of pesticides.[1] Many countries have regulations covering the use and handling of pesticides.[2]

Despite the legal framework to regulate the use of pesticides in Mexico,[3–5] many farmers in rural communities ignore these regulations.[6] Legislation alone often fails to ensure the safe use of pesticides.[7 8] Farmers' knowledge of the damage to health caused by pesticides is low.[9 10] There is an urgent need to train farmers on safely handling pesticides in the fields and at home.

Most educational intervention projects on safely handling pesticides encourage the correct use of personal protective equipment (PPE), reading safety instructions and the correct disposal of empty containers.[11–13] Some programmes emphasise hand washing, recognition of exposure and symptoms related to the use of pesticides and the importance of implementing educational training workshops for personnel handling pesticides.[14] Educational workshops sensitise people about their actions, increase their

concern about the environment and increase community cohesion.[15] The ideal educational process allows people to question themselves, reflect on environmental problems and generate possible solutions.[6] Training about safe pesticide use encourages farmers to adopt practices that reduce their and their family's risks. Most studies of educational interventions report on the impact on knowledge; what happens to farmers' pesticide management practices is less well documented.[13 16–19]

A pilot participatory educational programme among subsistence farmers in Mexico was acceptable within the community and led to improvements in knowledge and practices of pesticide handling.[20] Although educational interventions can achieve positive changes in knowledge and practices, most studies document these changes for a short time and do not include longer-term follow-up. We need longitudinal studies to document the longer-term sustainability of improvements after educational programmes.[19 21 22]

Several authors have identified limitations of educational interventions for protecting farmers against pesticide exposure. While farmers gain new knowledge about the safe handling of pesticides, they frequently complain that PPE is uncomfortable in hot weather, and they may be unable to afford to buy and maintain PPE.[22–24]

Rationale for the review

Inappropriate and unsafe pesticide use can damage both the environment and human health. Summarised in table 1, three previous systematic reviews of programmes to improve the safe use of pesticides (one including a meta-analysis)[25–27] covered 79 studies. Most of the studies included in the reviews came from developing countries, where subsistence agriculture is the primary agricultural activity. Most of the farmers in these countries have precarious livelihoods; many are illiterate and have limited access to PPE. The previous reviews included only publications in English. For relevance to Central and South America, it is important to include studies published in Spanish and Portuguese. Our review will include articles from previous reviews, additional reports in the grey literature and additional published reports. A preliminary search identified additional relevant studies not included in the previous reviews. Using another strategy, we found 7883 studies by improving the search algorithm. We selected a random sample of 10% to identify potential studies; we found a few studies that had already been considered in previous reviews. We carried out a further search using the Search Rabbit application. We input all the studies from the previous reviews and requested a search for similar studies. The search detected one additional study that met the inclusion criteria and had not been previously identified in the reviews. Using the 'snowball' strategy in Search Rabbit, we identified five additional studies that met the inclusion criteria.

Objectives

The review aims to summarise the impact of educational interventions on knowledge and reported behaviour of

Table 1 Existing systematic reviews on the effectiveness of educational interventions on safe handling of pesticides by farmers

Study	Aim of the review	Studies (n)	Epidemiological design of the included studies	Main conclusions
Afshari *et al*[25]	Summarise the literature on the effectiveness of interventions to promote pesticide safety and reduce pesticide exposure among farmers and farmworkers.	31	9 RCTs 22 quasi-experimental studies	The review highlights the significant effectiveness of educational programmes and some potential key elements of these interventions.
Ayaz *et al* meta-analysis[26]	Determine the effectiveness of educational interventions aimed at agricultural workers' knowledge, behaviour and risk perception for reducing the risk of pesticide exposure.	38	5 RCTs 2 CRCTs 17 quasi-experimental studies 14 single-group pretest–post-test study	The educational interventions are an appropriate method for reducing the pesticide exposure risks of agricultural workers. To increase the effectiveness of these interventions, the authors recommend using a theoretical basis, multiple education components and evidence-based practices.
Karimi-Shahanjarini *et al*[27]	Summarise strategies used in the cultural adaptation of interventions to reduce pesticide exposure in farmers and farmworkers and assess the effects of these strategies	10	10 RCTs	The review underscored the paucity and low quality of existing studies investigating culturally adapted interventions in reducing farmers' and farmworkers' pesticide exposure.

CRCTs, cluster randomised clinical trials; RCTs, randomised clinical trials.

pesticide users and to identify characteristics of more effective interventions.

Specific objectives are to:

- Conduct a systematic review of controlled trials of educational interventions to increase farmers' safe handling of pesticides.
- Conduct a meta-analysis of the impact of educational programmes on the outcomes of knowledge, attitudes and reported practices of farmers on safe handling of pesticides.
- Conduct subgroup analyses by type and intensity of educational interventions for knowledge and practice outcomes.

METHODS AND ANALYSIS

The study protocol follows the Preferred Reporting Items for Systematic Reviews and Meta-analysis Protocol guidelines.[28] We will use the procedures proposed by Cochrane's systematic review methodology to conduct the systematic review and meta-analysis.[29] We registered the study in the International Prospective Register of Systematic Reviews (PROSPERO) with CRD42023413028.

Search strategy

We will elaborate the search strategy based on the PICO format. Population: farmers who use pesticides. Intervention: educational interventions on the safe handling of pesticides. Comparison: reference group without the educational intervention. Outcome: knowledge, attitudes or reported behaviour about safe handling of pesticides.

Inclusion criteria

- Participants enrolled in the study met the criteria of being farmers who use pesticides.
- Studies that addressed educational interventions on the safe handling of pesticides by farmers.
- Studies including information on knowledge, attitudes or practices of farmers on the handling of pesticides.
- Research design was a randomised or non-randomised controlled trial.
- Articles published between 2000 and 2024 in English, Spanish or Portuguese.

Exclusion criteria

- Interventions without an educational component.
- Studies without a counterfactual comparison group.
- Studies not reporting on the outcomes of knowledge and/or attitudes and/or practices about handling pesticides.
- Studies not involving farmers.

We will search the digital databases of PubMed, LILACS, AGRICOLA, IMBIOMED, SciELO, Scopus, Web of Science and Embase. We will use Open Grey and the WHO to search the grey literature. We will use the terms: "Pesticide*", "Educational intervention", "Educational Program", "Environmental Education Program", "Knowledge", "Practical attitude* knowledge", "Safe handling of pesticide*", "Farmer*" and their equivalents in Spanish and Portuguese. We will manually search the grey literature and reference lists to identify more primary articles.[30] Table 2 shows the search terms for MEDLINE.

Table 2 MEDLINE search strategy

Search number	Search terms	Results
1	(Pesticid* [Title/Abstract]) OR ("Phosphoric Acid"[Title/Abstract]) OR ("Phenoxide"[Title/Abstract]) OR ("Polyoxin"[Title/Abstract]) OR ("Organophosphate"[Title/Abstract]) OR ("Bipyridyl*"[Title/Abstract]) OR ("Carbamat*"[Title/Abstract]) OR (Fungicid* [Title/Abstract]) OR (Herbicid* [Title/Abstract]) OR (Biocid* [Title/Abstract]) OR (Insecticid* [Title/Abstract])]) OR (Pyrethrins [Title/Abstract]) OR (Molluscacid* [Title/Abstract]) OR (Rodenticid* [Title/Abstract]) OR ("Pesticide exposure" [Title/Abstract])	185 022
2	(Intervention*[Title/Abstract]) OR (Effect* [Title/Abstract]) OR ("Education Intervention*"[Title/Abstract]) OR ("Education Program*"[Title/Abstract]) OR ("Environmental Education Program*"[Title/Abstract]) OR (Program* [Title/Abstract]) OR (Trainingn*[Title/Abstract])	10 612 723
3	("Knowledge*"[Title/Abstract]) OR ("Knowledge Attitude Practice"[Title/Abstract]) OR ("Safe handling of pesticides"[Title/Abstract]) OR ("Safety behavio*" [Title/Abstract]) OR (Safety [Title/Abstract]) OR (Prevention [Title/Abstract]) OR (Glove* [Title/Abstract]) OR (Mask* [Title/Abstract]) OR (Boot* [Title/Abstract]) OR (Control* [Title/Abstract]) OR (Protect [Title/Abstract]) OR (Evaluation* [Title/Abstract])	8 295 001
4	(Farmer*[Title/Abstract]) OR (Farming[Title/Abstract]) OR ("Farm worker*"[Title/Abstract]) OR ("Farmworker"[Title/Abstract]) OR (Agricultur*[Title/Abstract]) OR ("Crop production"[Title/Abstract]) OR (Horticultur*[Title/Abstract]) OR (Agronom*[Title/Abstract]) OR ("Agricultural worker*"[Title/Abstract]) OR (Camponês[Title/Abstract]) OR ("Trabalhador agrícola"[Title/Abstract])	210 212
6	1 AND 2	86 630
7	1 AND 2 AND 3	41 289
8	1 AND 2 AND 3 AND 4	7883

Study selection

We will enter identified articles in the Covidence software[31] and use it to eliminate duplicates. Two reviewers (MF-M and JS-A) will independently screen titles and abstracts of the studies to identify those potentially eligible. Two independent reviewers (BMS-G and CER-R) will screen the full text of the potentially eligible studies to confirm whether they meet the inclusion criteria. A third reviewer will make the final decision when there is a disagreement between the two reviewers (JL-S).

Data extraction

By improving the search algorithm, we found 7883 studies. We selected a random sample of 10% to identify potential studies. We carried out a further search using the Search Rabbit application. We input all the studies from the previous reviews and requested a search for similar studies. The search detected one additional study that met the inclusion criteria and had not been previously identified in the reviews. Using the 'snowball' strategy in Search Rabbit, we identified five additional studies that met the inclusion criteria. We included new six studies in this protocol.

Two reviewers (VMA-C and BMS-G) will independently extract data from the included studies using an extraction template and enter the information in Covidence. We will extract the following data: last name of the first author, year of publication, place of the study, objectives of the study, study design, size of the study groups, characteristics of the interventions, intensity of the interventions and timing of impact measurements; we will report associations on the risk difference of the outcomes between the intervention and control groups and mean differences, for dichotomous and continuous data and significance level. The primary outcomes are knowledge of the effect of pesticides on the environment and health, attitudes about safe handling of pesticides, reported practices such as using PPE, hand washing and safe storage of pesticides and conclusions. In case of missing data, we will contact the study authors and wait 2 weeks for a response. If there is no response, we will include the study in the descriptive analysis but not the meta-analysis.

Risk-of-bias (RoB) assessment

We will pilot the RoB tools on a subset of studies first. Two reviewers (VMA-C and JL-S) will independently assess the RoB in the studies. We will assess the RoB for randomised clinical trials with the Cochrane RoB tool for randomised trials (RoB V.2).[32] This tool assesses the RoB across five domains: (1) randomisation, (2) intervention deviations, (3) missing outcome data, (4) outcome measurement and (5) reporting bias. The level of risk is assessed as low: no bias across domains; high: high risk in at least one domain or significant concerns in multiple domains; or some concerns: concerns in at least one domain but not high risk.

We will evaluate the RoB in non-RCT with the Risk Of Bias In Non-randomised Studies - of Interventions (ROBINS-I).[33] We will assess five levels of risk across seven domains, low RoB: low RoB for all domains; moderate RoB, low or moderate RoB for all domains; serious of bias, serious RoB in at least one domain, but not at critical RoB in any domain; critical RoB: critical RoB in at least one domain; and no information: there is no clear indication that the study is at serious or critical RoB and there is a lack of information in one or more key domains of bias. We will resolve discrepancies between reviewers by discussion and agreement.

Data synthesis and analysis

We will conduct a descriptive analysis of the characteristics of the included studies and construct summary tables. For continuous variables, we will use means and SD when continuous data are expressed as medians and ranges; means and SD will be calculated as described by Hozo *et al*.[34] We will calculate percentages and risks for dichotomous data. In the meta-analysis, we will measure the effectiveness of the educational interventions on the knowledge, attitudes and practices of farmers about pesticides and handling of pesticides, based on the mean difference or the risk difference of the outcomes between the intervention and control groups, for continuous and dichotomous data, respectively. We will evaluate heterogeneity between studies with χ^2 and I^2 statistics (I^2 values of 0–25%, 26–50% and ≥51% equal low, moderate and high heterogeneity, respectively). We will choose a fixed-effects model when the I^2 statistic value is less than or equal to 50% and a random-effects model otherwise.

We will conduct subgroup analyses to examine the impact of interventions with different characteristics. We expect to consider subgroup analyses according to the focus of the education programme, duration of the intervention and community participation in the intervention design. We will conduct heterogeneity tests within subgroups.

We will do a sensitivity analysis to assess each study's influence on the combined impact measure, repeating the meta-analysis each time we remove an article. We will then quantify the total differences in the results. We will assess publication bias using a funnel plot and the Begg and Egger statistical test.[35 36]

We will analyse with the public domain software CIETmap[37] and the meta-analysis with the 'meta' package of the statistical language R.[38]

The Grading of Recommendations Assessment, Development, and Evaluation guidelines will be used to assess the strength of the body of evidence for primary outcomes, which will be graded into very low, low, moderate or high level.

Dissemination and research integrity

We will publish the results for use by the scientific community and Mexican health authorities through peer-reviewed scientific journals and posters or presentations at forums, congresses, symposiums and farmers' associations.

Ethics and dissemination

Ethical approval will not be required, as no primary data have been collected. Our results will assess the impact of educational interventions on pesticide users' knowledge and informed behaviour, identifying the characteristics of the most effective interventions. The study results will benefit farmers, their families and policy-makers. We will publish the review in a peer-reviewed journal and present the findings at academic conferences.

Patient and public involvement

None.

DISCUSSION

This systematic review will assess the available evidence on the effectiveness of educational interventions for safely handling pesticides among farmers. We expect heterogeneity of intervention duration, study size and educational content to affect summary estimates. We will perform a sensitivity analysis to measure the effect of each study on the global effectiveness estimate.

The review and meta-analysis will identify the likely magnitude of educational programmes' impact on farmers' knowledge and reported practices about safe handling of pesticides and identify characteristics—types and intensity of training—of more successful programmes. This could be useful for planning future programmes.

Contributors The protocol design and the revision were under BMS-G and VMA-C. BMS-G, VMA-C, JL-S, SP-S, MF-M, CER-R and JS-A made writing of the protocol. AC contributed to the design and writing of the document. NA provided technical supervision and contributed to the final document. All the authors read and approved the final document. VMA-C is the guarantor.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, conduct, reporting or dissemination plans of this research.

Patient consent for publication Not applicable.

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