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Too much to handle? Pesticide dependence of smallholder vegetable farmers in Southeast Asia

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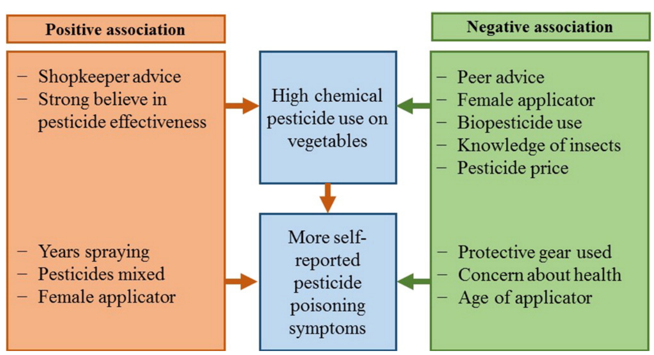
HIGHLIGHTS

- Vegetable farmers' pest management was studied in Cambodia, Laos, and Vietnam.
- Farmers were aware of health risks from pesticides, but considered pesticides indispensable.
- Low knowledge of beneficial and harmful insects was associated with more pesticide use.
- Farmers who sought advice from pesticide shopkeepers tended to use more pesticides.

GRAPHICAL ABSTRACT



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ABSTRACT

This study aimed to understand farmers' knowledge, attitudes, and practices regarding agricultural pest management and synthetic pesticide use in Southeast Asia. Data were used from 900 farm households producing leaf mustard (*Brassica juncea* (L.) Czern. et Coss.) and yard-long bean (*Vigna unguiculata* subsp. *sesquipedalis* (L.) Verdc.) in Cambodia, Laos and Vietnam. Farmers heavily depended on synthetic pesticides as their main method of pest control. Most farmers were aware of the adverse health effects associated with pesticide use and covered body parts while spraying, but also considered pesticides to be highly effective and indispensable farm inputs. Farmers were largely unable to distinguish between common beneficial and harmful arthropods. Greater knowledge about this was associated with less pesticide use while greater awareness of pesticide health risks was associated with fewer observed poisoning symptoms. For the average farm and while controlling for other factors, farmers who sought advice from friends and neighbors used 45% less pesticide, but those who sought advice from pesticide shopkeepers used 251% more pesticide. Pesticide use was 42% less when a woman was in charge of pest management and 31% less when farmers had adopted biopesticides. These findings suggest relevant entry points for interventions aimed at reducing pesticide dependence.

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1. Introduction

Agricultural pesticide use is rapidly increasing in many developing countries, but particularly in Southeast Asia (Kunstadter, 2007; Schreinemachers and Tipraqsa, 2012). Annual growth in pesticide imports is estimated to be 61% for Cambodia, 55% for Laos, and 10% for Vietnam (Schreinemachers et al., 2015). The fast rate of this increase poses enormous challenges to manage the associated risks to people and ecosystems. For instance, Skretteberg et al. (2015) studied fruit and vegetables imports from Southeast Asia into four European countries and found pesticide residues above maximum residue limits in 33% of samples from Vietnam and 9% from Thailand. It is generally well understood that pesticides pose the greatest risk to applicators and their families, particularly in developing countries where a large segment of the population is involved in agriculture, spraying is done manually with simple equipment, and applicators are not fully aware of the risks of exposure (Jensen et al., 2011; Mengistie et al., 2017; Praneetvatakul et al., 2013).

In Southeast Asia, such farm-level risks are relatively well documented for Thailand and Vietnam (e.g. Grovermann et al., 2013; Hoai et al., 2011; Hoi et al., 2009; Houbraken et al., 2016; Lamers et al., 2011; Panuwet et al., 2012; Poramacom, 2001; Praneetvatakul et al., 2013; Riwthong et al., 2015; Schreinemachers et al., 2011). However, there is a lack of similar knowledge for lower income countries such as Cambodia and Laos (exceptions being Jensen et al., 2011 for Cambodia and Brown and Khamphoukeo, 2010 for Laos). There, widespread pesticide use is a much more recent phenomenon and regulatory frameworks and monitoring systems are even weaker than those of their higher income neighbors (McCann, 2005; Schreinemachers et al., 2015).

The development of policies and regulations addressing the issue requires information about current pest management practices and associated risks at the farm level. The objective of this study was to improve our understanding of farmers' knowledge, attitudes and practices regarding pest management in Southeast Asia. Our study focused on vegetables because pesticide use is particularly high for these crops, which are susceptible to a large number of arthropod pests and diseases while consumers prefer unblemished pest-free vegetables.

2. Data and methods

2.1. Conceptual framework

This study applied the concepts of knowledge, attitudes and practices (KAP). A KAP assessment tells us what people know about the problem, how they feel about it, and how they currently behave. This framework assumes that a change in practices is the cumulative result of a change in knowledge and attitudes. The separation between knowledge, attitudes and practices has been frequently employed in studies on pesticide exposure (e.g. Brown and Khamphoukeo, 2010; Karunamoorthi et al., 2012; Pasiani et al., 2012; Recena et al., 2006; Yang et al., 2014). The information obtained from such studies is useful to target policy interventions to close knowledge gaps or to correct prevailing misconceptions.

Knowledge here refers to farmers' understanding of pests, pesticides and good agricultural practices. Three exercises, available from the authors on request, were used to test farmers' knowledge. The first exercise showed 12 color photos of common arthropods, including six harmful arthropods (e.g. flea beetle, diamondback moth, and pod borer for vegetable legumes) and six beneficial arthropods (e.g. spider, ladybird beetle, and lacewing). Respondents had to indicate which arthropods they thought damaged crops. In the second exercise, respondents were asked to match five photos of adult insects to five photos of their larvae/nymphs. In the third exercise, respondents were presented with six pesticide safety pictograms commonly found on the label of pesticide containers in all three countries, and were asked to explain the meaning of each. For each test, the proportion of correct answers was calculated. The use of pesticide safety pictograms to test farmers' knowledge has been done in previous studies (e.g. Mengistie et al., 2017; Pedlowski et al., 2012), but testing farmers' knowledge about the role and lifecycle of arthropods has, to our knowledge, not been done before.

Attitudes here refer to farmers' beliefs about pesticide effectiveness and health effects, including possible misconceptions. It was measured using 16 statements listed in Appendix Table A1. The initial statements were taken from LePrevost et al. (2011) but major adjustments were made to make them more relevant to the local context and understandable to farmers. To keep it simple, farmers could answer "agree" or "disagree." Eight statements measured farmers' beliefs about pesticide health risks (e.g. "Pesticides can enter the body through the skin") and six statements recorded farmers' belief about the necessity and effectiveness of pesticides (e.g. "Using pesticides increases farm profits" and "Commercial vegetable production without pesticides is impossible"). Each set of statements was made into an index.

Self-perceived pesticide poisoning symptoms were also recorded. We listed 14 possible symptoms (e.g. headache, vomiting, dizziness, abdominal pain, skin rashes, and blurred vision) and asked each respondent whether they did or did not experience the symptom after spraying pesticides. This test is commonly applied in pesticide risk studies (e.g. Dasgupta et al., 2005; Jensen et al., 2011). The total number of symptoms was expressed as a score. Farmers' perceptions might be quite different and less accurate than that of trained experts, but nevertheless provide important information because farmers decide on a course of action based on their own perceptions of reality.

Practices here refer to farmers' actual behavior (decisions, actions) that demonstrate knowledge of and attitudes toward pest management and pesticides. Five alternative measurements were used that all referred to the respondent's most recently harvested vegetable parcel. First, the quantity and the purchase value of pesticides used was recorded by asking for the names of all pesticide products used, the number of times the product was applied, the average quantity per application, and the amount of money spent. Second, the number of times the farmer sprayed was recorded. Third, we recorded the use of protective gear (e.g. boots, mask, gloves, and hat). Fourth, we asked if different pesticides were mixed in a single spray and if yes, how many. Fifth, the average number of hours or days between spraying and re-entering the field (also known as the re-entry interval) and between last spraying and harvesting (also known as the pre-harvest interval) was recorded.

2.2. Data

Our study collected farm-level data from Laos, Cambodia and Vietnam. These countries represent a scale of average levels of pesticide use intensity from low average levels in Laos to high levels in Vietnam (Schreinemachers et al., 2015). The study's scope was narrowed to leaf mustard (*Brassica juncea* (L.) Czern. et Coss.) and yard-long bean (*Vigna unguiculata* subsp. *sesquipedalis* (L.) Verdc.) as two vegetable species commonly cultivated in the three countries. Leaf mustard, also known as green mustard or mustard greens, is cultivated year-round, but cultivation peaks in the cooler period from October to March. In Laos and Vietnam yard-long bean cultivation is mostly carried out during the hot season starting from April, but in Cambodia it is mostly grown in the cooler season from November to March.

The study started with focus group discussions in two selected villages per country to get a better understanding of the issues and to inform the subsequent questionnaire development. The questionnaire had 14 pages and is available with the online version of this article. The questionnaire was designed in English, translated into Lao, Khmer and Vietnamese, and tested with farmers before the start of the data collection. Minor adjustments were made to tailor the questions to each country.

We took a representative sample of farmers from the main production areas and main production season per country using a stratified random sampling strategy. There are unfortunately no lists of bean