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Factors Associated with Farmer's Behaviors of Using Pesticide Safely: Exploratory Factor Analysis

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Abstract Farmers used a large amount of pesticides in their cultivation process particularly those who aimed at selling their produces to the market. These posed a high risk of pesticide poisoning. Their family members and consumers were also at risk. The study aimed to investigate the factors associated with farmer's behaviors of using pesticides safely. The cross–sectional study was carried out into two stages. The first stage: a qualitative study was performed in 17 farmers to seek factors related to the farmers' safe use of pesticides. The second stage: a quantitative study was using exploratory factor analysis (EFA) to analyzes data of 230 randomly farmers to identify factors associated with the farmers' safe use of pesticides. The results reveals that farmers' behaviors of using pesticide safely were associated with 8 factors including 1) Social reasons, 2) Personal Protection, 3) Confidence in residue-free cultivation, 4) Eagerness to learn, 5) Risk Perception, 6) Practices, 7) Knowledge of Toxicity and 8) Economic reasons. The safe use of pesticides among farmers was associated with several factors. Further, the programmes aiming at changing farmers' behaviors of pesticide use need to address these multi-dimensional factors.

Keywords Exploratory Factor Analysis, Using Pesticide safely, Farmers

1. Introduction

Using pesticides in agriculture occurred when producing system was changed from traditional agriculture system to market-oriented system. In Thailand, pesticides have been used in agriculture for more than 50 years in accordance with the national development plans promoting agriculture produces for the world markets. The amount of pesticides used in cultivation has increased since then. Pesticide exposure is one of the most important occupational risks among farmers in Thailand (Ecobichon, 2001). Pesticides are the major cause of acute and chronic illnesses. Long term exposure to chemicals was related to many kinds of illnesses, for example cancer, abnormal reproductive system, and immunological system (Maroni and Fait, 1993). It could change human genetic substance (Lu Y, et al. 2000). Agriculturists all over the world had many kinds of cancers e.g. lymphoma, leukemia, brain cancer, stomach cancer, and prostate cancer (Fuortes, 1996). Acute illnesses often occurred after exposure to chemicals in a short time. These illnesses could be found in farmers and their family members. There were about 3.5 – 5 million patients in a year suffered acute poisoning from chemicals all over the world, and 300,000 patients would died in a year (Gunnel and Eddleston, 2003). About 3% of agriculturists in developing countries exposed to poisonous chemicals, therefore, there would be 25 million farmers in a year experienced pesticide poisoning (Jeyaratnam, 1990). Pesticides have also serious effects to the environment. Pesticide residuals always contaminate the soil, air, water and produces. Because only 0.2% of sprayed pesticides went directly to insects, the rest, 99.8 % was left contaminating in water, soil surface, and underground (National Research Council, 1984). It caused damages to almost every kind of living things in the environment. For the consumers' health, the pesticide residues in the produces affect a lot of people. It can be said that agriculture is one of high risk occupations, and one of the major causes of health problems. Farmers' behaviors of pesticide use are therefore crucial.

Programmes to promote the safe use of pesticide have been tried in many settings to encourage self protection and pesticide residue-free cultivation. In U.S.A., health knowledge and trainings under Worker Protection Standard (WPS) were provided to farmers. However, this method still had limitation. If farmers lacked of confidence, they would be against or refused to change their behavior (Austin, et al 2001). Therefore, encouragement or supporting farmers to have safe behavior, making farmers be confident that they can practice safe behavior should be stressed, and it should be stressed on both individual and family levels. The promotion of pesticide residue-free cultivation in accordance

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with Good Agriculture Practices (GAPs) is another key strategy (FAO, 2003). Specific methods to verify the farmer's use good practices are employed. The standards were set by the Department of Agriculture of the Thai Ministry of Agriculture and Cooperatives. The programme aiming at changing behaviors of farmers who cultivating crops for market sale need to address many factors related to safe use of pesticide behaviors. Eventually, these should enable farmers to do pesticide residue-free cultivation.

The study therefore aimed at identifying factors related to safety behaviors among farmers who used pesticides. The results may aid in designing a good model of behavior change to encourage farmers' adoption of safety behaviors.

2. Material and Method

The cross–sectional study collected data using both of qualitative and quantitative methods. Literature reviews were performed to initially identify factors related to pesticide residue-free cultivation found in previous researches. Results of the reviews guided the construction of questions for in-depth interviews and focus group discussion among 17 farmers who participated in residue-free cultivation for market sale and had been approved for Good Agriculture Practices (GAPs). The GAPs are the specific methods to verify the farmer's practices according to the standard set by the Department of Agriculture of the Thai Ministry of Agriculture and Cooperatives.

The data was transcribed and checked for completeness with written notes. The content analysis was carried out by both inductive and deductive processes. The inductive process firstly began with the process of open coding, copying and reading the transcribed to define the coding unit, and checking the coding consistency (Weber, 1990). Secondly, we created categories from the coded data then the lists of categories are grouped under higher order headings (Burnard, 1991). Thirdly, we did an abstraction for each category by giving names using content-characteristic words. Subcategories with similar events and incidents are grouped together as categories and categories are grouped as main categories (Dey, 1993).

The deductive process included testing categories, concepts or models, based on the principles of content analysis. Data validation was carried out using 4 triangulation processes: data triangulation, investigator triangulation, theory triangulation, and methodology triangulation (Thurmond, 2001). The data were itemized and categorized according to the objectives of the study. There was also a content analysis by distinguishing, interpreting, and comparing to find relations in patterns and phenomenon in order to reach a conclusion of the related factors (Silverman, 2006). The results were then utilized to write a set of questions or variables in an interview questionnaire. The variables were developed to test knowledge, attitudes and practices of the farmers.

The interview questionnaire used Likert scale for variables testing attitudes. The scale was divided into five degree ratings. The first degree means "strongly disagree". The second degree means "disagree". The third degree means "undecided. The fourth degree means "agree". The fifth degree means "strongly agree".

The variables testing farmers' practices also adopted the five degree rating scale using Likert scale. The first degree means the respondents' confidence to follow such practice "at the lowest level or they could not at all do so". The second degree means the respondents' confidence to follow such practice "at the low level or they could sometimes do so". The third degree means the respondents' confidence to follow such practice "at the medium level". The fourth degree means the respondents were confident to "often follow such practice". The fifth degree was the respondents were confident to follow such practice "all the time or almost all the time".

The variables measuring knowledge were determined to express two different answers, "yes" or "no". When the respondents answered "yes", it counted as one point. When the answer was "no" or "unknown", it received zero point.

The quality evaluation of the interview questionnaire consisted of validity, and reliability. For content validity, it was assessed and agreed by three experts with expertise in pesticide health effects and safe pesticide use behaviors. The item-objective congruence index (IOC) was used to assess the content validity. The content specialists are asked to assign a value of +1, 0 or -1 for each item, depending on the degree to which they measure specific objectives listed by the test developer. A value of 1 indicates that all experts agree that the item is clearly measuring that objective. A value of -1 indicates that the experts believe the item was not defined to measure. The value of .50 indicates "a minimum" and value of 1 is "good" (Rovinelli and Hambleton, 1977).

The process of evaluation item reliability was carried out by trying out the set of variables with 30 farmers who practiced residue-free cultivation. As for the aspect of attitudes, the set of variables was tested for its internal agreement with the method of Cronbach to find out Cronbach's Alpha coefficients. Reliability of the knowledge was tested using Kuder Richardson coefficient, or K-R20 (Kuder & Richardson, 1937) which claimed that a good coefficient should be 0.7 or more. The questionnaire was language improved before being implemented.

For the quantitative data analysis, the exploratory factor analysis was carried out using the Principle Component Analysis to extract a set of factors. This was done to reduce the number of the variables and to arrange the factors to be included in the multivariate analyses. The analysis began to test whether the sample size is adequate by the Kaiser-Meyer-Olkin (KMO-test) which is greater than 0.5, and the inter-correlation can be checked by using Bartlett's test of spherity, which is greater than 0.00001. The factors retained based on their eigenvalues larger than 1 (Guttman-Kaiser rule), account for about 70-80% of the variance. Factors rotation was using orthogonal rotation with varimax rotaion. Only factors loading with an absolute value greater than 0.4 (which explain around 16% of variance) were included (Stevens 1992). The author considered the items with factor loading values of 0.5 to be acceptable for retention in the factors. Variables lower than this, were cut out of the factors making the themes shorter and optimizing practicality.

The interview questionnaire was used to collect data from 387 registered farmers doing cultivation for market sale in Nong Ruea district, Khon Kaen province. Information about GAPs was obtained from the records of the Nong Ruea Agriculture Extention Office. The results of the try-out phase were used to calculate the size of samples by simple random sampling. The calculation showed that 230 samples were needed. Inclusion criteria were 1) the farmers must be 20 years old or older, 2) be leaders of families or bore an authority on planting in families, and 3) be literate. The studied unit was one farmer from one family growing 4 kinds of vegetable: cabbage, cow-pea, egg plant, chili and cucumber and they used a large amount of pesticides. The land used in cultivation was at least 0.1 acre, and have been growing them for at least 1 year. They grow the crops continuously at least 3 month/a year. The SPSS version 13 for windows use for this analysis.

Ethical Review

This research proposal was reviewed and approved by the Human Research Ethics Committee of Khon Kaen University (HE 531347).

3. Results

Demographic Characteristics

Table 1. Demographic and Occupational Characteristics of Farmers

	Characteristics	Numbers (N = 230)	%
Genders			
	Males	179	77.8
	Females	51	22.2
Ages			
	Under 39 years	35	15.2
	40 – 49	85	31.0
	50 -59	80	34.8
	60 up	30	13.0
(Mean = 49, SD = 9.5, Min = 28, Max = 80)			
Marital Status			
	Single	6	2.6
	Married	217	94.3
	Widow(er)/divorced/separated	7	3
Main occupations			
	Agriculturists	229	99.6
	House wives	1	0.4
Education Background			
	Primary	199	86.5
	Secondary/lower voc. Cert.	29	12.6
	Assoc. degree/ higher voc. Cert.	2	0.9
Yearly income			
	Lower than 25,000 Baht	34	14.8
	25, 001 – 45, 000 Baht	28	12.2
	45, 001 – 65, 000 Baht	66	28.7
	65, 001 – 85, 000 Baht	26	11.3

Table 1. Demographic and Occupational Characteristics of Farmers (Cont.)

Characteristics	Numbers (N = 230)	%
Yearly income		
85, 001 – 105, 000 Baht	43	18.7
More than 195, 000 Baht	33	14.3
(Mean = 72.855, SD = 51225.314, Min = 5,000, Max = 315,000)		
Yearly income (from selling crops)		
Lower than 25,000 Baht	80	34.8
25, 001 – 45, 000 Baht	66	28.7
45, 001 – 65, 000 Baht	47	20.4
65, 001 - 85, 000 Baht	12	5.2
85, 001 – 105, 000 Baht	17	7.4
More than 105, 000 Baht	6	3.5
(Mean = 41,909, SD = 32359.391, Min = 1,000, Max = 200, 000)		
The experience from training course of residue-free cultivation.		
No	100	43.5
Yes	130	56.5
The experience in receiving information about residue-free cultivation.		
No	18	7.8
Yes	222	92.2
Land size used for cultivation for market sale (Ngan) (1 Ngan = 0.25 of a rai = 0.1 acre)		
1 – 4	54	23.5
5 – 8	80	34.8
9 – 12	49	21.3
13 – 16	30	13.0
17 up	17	7.4
(Mean = 10, SD = 6.087, Min = 1, Max = 40)		
Length of time spent on cultivation for market sale (Years)		
1 – 5	68	29.6
6 – 10	72	31.3
11 – 15	38	16.5
16 – 20	32	13.9
21 up	20	8.7
(mean = 11, SD = 7.468, Min = 1, Max = 40)		
The experience in received information about residue-free cultivation.		
No	18	7.8
Yes	222	92.2
The experiences in training course on residue-free cultivation.		
No	100	43.5
Yes	130	56.5

A majority of farmers (77.8%) were male, with average age of the individuals 49 years and 34.8% were between from 50 to 59 years old. Most of them (99.4 %) were married. Most were primary school educated (86.5%). Their major occupation was agriculturists (99.6%). The average income of each family was 72,855 Baht, and the income from their crops was 41,900 Baht a year. Most of them (92.2%) have ever received information about residue-free cultivation. More than half of them (56.5%) had ever attended the training course on residue-free cultivation. The land used in cultivation was 2 and a half rais (around 1 acre) /a family averagely, and have been doing cultivation for 11 years. The descriptions are shown in table 1.

First: Qualitative methods, to Studying the factors related to pesticide residue-free cultivation

The finding showed that the factors involving pesticide residue-free cultivation were in accordance in four aspects as follows: The first aspect was health, which means the farmers perceiving the risk of pesticide poison to themselves, consumers and environment. The second aspect was knowledge, which means the farmers perceiving knowledge in both of safe use of pesticides for themselves and the pesticides residue-free cultivation methods, the knowledge can be conceptualized as a mixture of past and present experiences. The third aspect was economics, which means the pesticide residue-free crops can be sold with higher price and needed by customers. The fourth aspect was social, which means the farmers' are supported to do pesticide residue-free cultivation with budget, knowledge, marketing, publicizing from involved organizations e.g. Tambon administrative organizations, Tambon agriculture officials, and health centers to encourage the pesticides residue-free cultivation.

The details from each factor were brought to write questions or variables in an interview questionnaire to identify factors associated with behaviors of using pesticide safely. The questions were to explore 3 aspects of behaviors: knowledge, attitudes and practice. The items testing knowledge contained questions that could point out each farmer whether or not he or she could demonstrate principal knowledge about safe use of pesticides and knowledge about pesticides effects on human health and environment. There obtained 2 main variables (with 9 sub variables). As for the aspect of attitudes, there were 20 main variables to measure determination or reliability towards safe use of pesticides and benefits from safe use of pesticides. As for the aspect of practice, there were 11 main variables obtain from self protective behaviors from pesticides' poisons and the farmers' deduction and abandonment of pesticides in planting in regard to academic principals. There were 33 principle variables (with 40 sub variables). The primary quality evaluation: the content validity was assessed and agreed by three experts. The results showed the item objective congruency index, or IOC, of each item, which equaled 1 part of reliability. When the test was tried out, it revealed that the variable measuring knowledge showed Cronbach' coefficient at 0.776, as for the aspect of attitudes showed Conbrach' coefficient at 0.818.

Second: Quantitative methods, Factor Analysis variation

The collected data from the interview forms were brought to do exploratory factor analysis using Principal Component Analysis (PCA). The result of the test confirmed that it was in accordance with the assumption. The important findings were that 1) the value of Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) was 0.822. It showed that the data were very suitable to be analyzed their factors. 2) The value of Bartletts Test of Sphericity was 2601.318 (P value 0.000). It showed that the co-matrix was significantly different from the specific matrix at 0.000. The results of the two statistic tests showed that the variables were reliable to measurement, and they were suitable to be analyzed their factors.

The 33 principle variables or noticed variables were brought into Orthogonal component analysis by Varimax. From the results of extraction sums of squared loading and the rotation sums of squared loading, the questions with high relations were combined to make new 9 factors using Eigen values. The value which was more than 1, or the variance of each factors that could be explained with noticed variables were used as criteria. The 9 factors could explain their variance 61.42%. After considering the variables of each factor, it was found that the variables in the factor 9 could not communicate the meaning. Therefore the 9^{th} factor was deleted. There were 8 factors left (factor 1 – factor 8), and they could be explained their variance 58.42%.

The 8 factors were as follows. The first factor revealed the eigen values 6.711, percentage of variance 20.337 and cumulative 20.337. The second factor revealed the eigen values 3.478, percentage of variance 10.540 and cumulative 30.877. The third factor revealed the eigen values 2.499, percentage of variance 7.422 and cumulative 38.299. The fourth factor revealed the eigen values 1.622, percentage of variance 4.917 and cumulative 43.216. The fifth factor revealed the eigen values 1.457, percentage of variance 4.415 and cumulative 47.631. The sixth factor revealed the eigen values 1.269, percentage of variance 3.847 and cumulative 51.477. The seven factor revealed the eigen values 1.175, percentage of variance 3.559 and cumulative 55.037. The eight factor revealed the eigen values 1.090, percentage of variance 3.304 and cumulative 58.341.

The criteria used to arrange the variables in each factor depended on factor loading. Therefore, to make each variable clearly reflect on factor associated to behavior change in farmers using pesticide safely, it was determined that the variables selected to be in the group of the factor must have loading value at least 0.5, and they must not have loading value close to the variables in other factors. Therefore, there were 23 main variables (with 30 sub variables) left. Since the variables in each factor more clearly reflect the meaning of the factor, the name of each factor came from the meaning of the set of variables in each factor.

Factor 1 was composed of 4 variables with loading 0.776 to 0.857, eigen values 6.711, and it can be explained 20.377% of the factor. The name of the factor was Social. Factor 2 was composed of 5 variables with loading 0.711 to 0.796, eigen values 3.478, and it can be explained 10.540%. The name of the factor was Personal Protection. Factor 3 was composed of 4 variables with loading 0.612 to 0.656, eigen values 2.449, and it can be explained 7.422%. The Name of the component was Confidence. Factor 4 was composed of 2 variables with loading 0.580 to 0.726, eigen values 1.662, and it can be explained 4.917%. The name of the factor was Eagerness to learn.

Factor 5 was composed of 2 variables with loading 0.775 to 0.808, eigen values 1.457, and it can be explained 4.415%.

The name of the factor was Risk Perception. Factor 6 was composed of 2 variables with loading 0.528 to 0.793, eigen values 1.269, and it can be explained 3.848. The name of the factor was Practices. Factor 7 was composed of 2 variables with loading 0.667 to 0.683, eigen values 1.175, and it can be explained 3.559% The name of the factor was Knowledge of Toxicity. Factor 8 was composed of 2 variables with loading 0.653 to 0.806, eigen values 1.090, and it can be explained 3.304. The name of the factor was Economic.

4. Discussions

The factors involving pesticide residue-free cultivation from the first stage were composed of 4 aspects: the effects on human health, knowledge, economic, and social. The description of the 4 aspects were brought to write questions or variables in an interview form to assessed the confidence of pesticides use safety. There were 33 main variables (40 sub variables). The interview form was basically evaluated, and was used to collect data in the pilot study. Because of the results of Exploratory Factor Analysis, the variables were reduced to 23 main variables (33 sub variables). The variables could be grouped to be 8 factors associated with farmers using pesticide safely reflecting descriptions in each factor. The factors were named according to the descriptions of the factors in each group. There were, social, personal protection, confidence in residue-free cultivation, eagerness to learn, risk perception, practices, knowledge of toxicity, and economic reasons.

The data reflecting on the pesticides use safety behavior associated with several factors. The findings differed from the results of other studies. For instance, Polanco (2012) found that the most relevant factors related to pesticide use included, individual: beliefs, attitudes and knowledge. Interpersonal: family support and cultural acceptance of pesticide use. Economic: fear of living within financially unviable constraints, market conditions or tolerance of pesticide use and exposure and onset of negative reactions when stopping pesticide use. Political: deficient regulations for controlling pesticide use control, and adequate utilization of protective equipment.

The 8 factors can be applied to the development of changing behaviors of farmers, at individual, organizations, and policy levels. For individual, the factors can used to create the tools to measure the changing behaviors, e.g. the readiness scale for changing farmers' pesticide use behaviors, to developed the appropriate intervention for changing behaviors of using pesticide safely to protect themselves from pesticide exposure and to encourage adoption of these behaviors in reducing or stopping using pesticides in cultivation process, etc. For organization or policy levels, the factors can be used to provide policy makers with prioritized information on farmers' behaviors and to make the most efficient and effective uses of resources in behavioral change programmes.

5. Conclusions

The first part of the findings showed that the factors involving 4 aspects of pesticide residue-free cultivation. They were health, knowledge, economic, and social. The descriptions of each aspect were used to write questions or variables in an interview form. There were 33 main variables (with 40 sub variables). The interview form was then basically evaluated the primary quality: validity and reliability before being used to carries out in a pilot study. The data were analyzed by exploratory factor analysis (EFA) by Principle Component Analysis (PCA) to reduce the variables into 23 main variables (30 sub variables). They were grouped into 8 factors associated with farmers' using pesticide safely behaviors including 1) Social reasons, 2) Personal protection, 3) Confidence in residue-free cultivation, 4) Eagerness to learn, 5) Risk perception, 6) Practices, 7) Knowledge of toxicity, and 8) Economic reasons, respectively.

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