The Development of a Readiness Scale for Changing Farmers' Behaviors of Using Pesticides

Duangjai Wichai PhD*,
Pattapong Kessomboon MD, PhD**, John F. Smith PhD**

** Khon Kaen Provincial Health Office, Khon Kaen, Thailand*
*** Department of Community Medicine, Faculty of Medicine, Khon Kaen University, Khon Kaen, Thailand*

Background and Objective: *Inappropriate pesticide-using behaviors impose significant negative impacts on health and environment. Developmental programs to change such behaviors of farmers should target those who are ready to change in order to achieve efficiency. The objective was to develop a readiness scale in changing behavior of using pesticides of farmers. The scale of this study is expected to be used in recruiting target farmers in developmental programs.*
Material and Method: *A cross-sectional study was divided into two phases. The first phase, qualitative method, performed on 17 farmers participated to seek factors related to the farmers' safe use of pesticides. The second phase, quantitative method to develop the readiness scale, an exploratory factor analysis (EFA) was analyzed on 230 farmers and was randomly selected to measure the scale's construct validity, internal consistency (reliability), one-dimensionality and the appropriate cut-off point, respectively.*
Results: *Farmers' pesticide use, safety behaviors involved several factors, and are applied to create a set of questions on the readiness scale; there were 33 main items (with 40 sub-items), which could be grouped into 8 factors associated with farmers using pesticide safety, the scale, the best way to predict farmers who are ready to change. Finally, they were reduced to 23 main questions with 30 sub-questions in the scale.*
Conclusion: *The development of a readiness scale application of changing behaviors as a guide, to assess content validity using index of item-objective congruence measurement (IOC), the exploratory factor analysis was used to determine an item and to test reliability on the scale. The scale can be a useful tool for recruiting farmers into intervention program in changing pesticide use, safety behaviors.*

Keywords: *Readiness scale, Changing behavior, Pesticide use*

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Agricultural use of pesticides has a significant, negative effect on health and environment. In 2010, Thailand imported 118,152 tons of chemicals[1], ninety percent of which were used in agriculture[2]. Pesticide exposure is one of the most important occupational risks among farmers in Thailand[3]. Growing vegetables for market consumes a large amount of chemicals or pesticides in cultivation process[4,5]. The effectiveness of these behaviors to reduce their pesticide exposure was associated with lower levels of exposure[6]. However, farmers have different levels of knowledge of chemical usage risks and different levels of readiness to change their pesticide-using behaviors. Therefore, creating a scale to assess farmers' readiness for changing pesticide-using behaviors would be a useful development in an effort to improve worker health and safety practices.

Behavior change readiness scales have been developed for a number of behavior change areas, e.g. reducing drug, alcohol and cigarette use and food consumption[7]. They consider the five stages in a process of changing. Another prominent behavior change model is the theory of diffusion of innovation (DOI)[8,9] which was widely used over the past few years. According to this theory, participants will adopt new ideas or practices at different stages in a behavior change process, and divide them into five stages in the adoption process and estimate the percentage of each category, which in fact, are very similar to the proportions found in a normal bell-curve. The concepts of both theories are similar, especially in the third stage

Correspondence to:
Kessomboon P, Department of Community Medicine, Faculty of Medicine, Khon Kaen University, Khon Kaen 40002, Thailand.
Phone: +66-83-1456437
E-mail: pattapng@kku.ac.th

of the behavior changing process i.e. the preparation and decision stages. Both stages involve considering a person's state of readiness and willingness to change. The Self-direct Learning Readiness Scale (SDLRS)[10] is an instrument that was developed to measure the complex of attitudes, skills, and characteristics that comprise an individual's current level of readiness to manage his or her own learning, has been used widely around the world. Scale development consists of two phases. First, the Delphi survey to determine the content of the SDLRS. Second, the initial try-out, item analysis data used to select items for revision and to estimate the parameters of the test. Scale scores were to measure current levels of readiness; the scores can divide people into five different levels of readiness: low, below average, average, above average and high. Then they can be identified by two major groups of readiness, including, high level of readiness (50% of person) and low level group, the levels of readiness found in a normal bell-curve according the DOI concept.

The development and validation of the SDLRS for nursing education was conducted in three stages[11]. Firstly, the item pool was developed following a comprehensive literature search. Later the Delphi technique was used to gain consensus from an expert panel of 11 nurses. Finally, the resultant item pools were piloted on a sample size and a principle component analysis was used to establish the underlying factor structure of the items in the instrument. Cronbach's coefficient alpha, and item-to-total correlations were analyzed to measure the scale's construct validity, internal consistency (reliability), and one-dimensionality, respectively.

The development of a readiness scale for changing farmers' pesticide use behaviors adopted the key features of the behavior change models. In assessing individuals' readiness/motivation for change, we can identify two groups of population: one-half is the early adoption group interpreting, that they are ready to change. The other is the late adoption group interpreting, that they are not ready to change. Cut-off point of the readiness scale is based on the scale score. The higher scores mean the farmers have high readiness. The scale is expected to be useful in identifying potential early behavior change adopters in farmer development programs.

Material and Method

In this cross-sectional study aimed to develop a behavior change, readiness scale, to be divided into two phases. The first phase used qualitative methods to investigate factors related to farmers' safe use of pesticides. The second phase used quantitative methods to develop a readiness scale.

Study setting and participants

The participants were 387 farmers growing vegetables for sale who worked in the Nong Ruea District of Khon Kaen Province, Thailand.

There were two participating groups: in the exploratory stage 12 farmers participated in an exploratory focus group discussion, a further five were engaged in subsequent in-depth interviews. The first draft of the readiness scale was piloted on a convenience sampling and a randomly selected sample of 230 were administered the final research version of the scale. This sample size of 230 was calculated using estimate a proportion equation. This sample was drawn using random sampling tables from farmers registered at the Nong Ruea Agriculture Extension Office. The following inclusion criteria were used: participants must be at least 20 years old, be leaders of families, or an authority on planting in the families, must be literate, and a farmer from one family growing of vegetables.

Phase one: investigation of factors related to farmers' pesticide use, safety behaviors

This phase began with a literature review were performed to initially identify factors related to farmers' pesticide use safety behaviors, and use guidelines of the Good Agriculture Practice (GAPs) are the specific methods to verify the farmer's use good practices[12] and the standards of the Department of Agriculture of the Thai Ministry of Agriculture and Cooperatives.

Data from the literature review were used as a model to create questions for a focus group discussion, and later in-depth interviews. The questions covered farmers' knowledge, attitude and practices related to their handling of chemical pesticides. Content analysis may be more flexible or more standardized, but generally, it can be carried out in both inductive and deductive analysis processes are represented as three main phases: first, preparation, started with collecting suitable data for content analysis, to making sense of the data, and selecting the unit of analysis. Second, organizing, beginning with open coding, coding sheets, grouping, categorization and abstractions and reporting the results[13]. Deductive approach used for testing the data from the literature review was used as a model to create questions for a focus group discussion, and later in-depth interviews. The details from the two parts were brought to write a set of questions or variables in an interview, the variable must be able to test all three aspects of knowledge, attitude, and practice.

Phase two: The development of the readiness scale

The development of the readiness scale adopted the process proposed by Richard et al[14]. The process consisted of various procedures including: 1) clarifying the issues needing investigation, 2) generating an item pool, 3) validating the item pool by experts, 4) pilot testing items on a participant sample, and 5) evaluation of item performance using factor analysis and categorizing the readiness criteria in the scale. Details of the steps were as follows.

First, Item generation, three issues underpinned the generation of the items, 1) items needed to reflect factors related to the safe use of pesticides, 2) items needed to reflect principles from trans-theoretical model (TTM)[15], that is, assess participants' confidence or determination to change their behaviors and whether they could evaluate pros and cons from behavior change and 3) the item pool must measure all three aspects of knowledge, attitudes, and practice relating to safe pesticide use. All Attitude and confidence about practice items were rated using a five-point Likert-type scale. "Attitude" items ratings ranged from one, "strongly disagree", to five, "strongly agree. "Confidence to follow practice" items were rated from 1, "at the lowest level, or, cannot carry out this practice at all", to five, "confident to follow this practice all the time, or, almost all the time". "Knowledge" items used a binary measure: yes, or no, with yes being scored as 1 point, and no as zero.

Second, validity and reliability: Items were assessed for content and construct validity of a number of items perceived to reflect readiness to change pesticide use safety behaviors by agreement between three health experts with expertise in pesticide health effects and safe pesticide use behaviors. This approach is widely applied to the development of research scales. Rovinelli provided the content validity of item-objective congruence index (IOC) procedure[16]. Content specialists are directed 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 indicate that all experts agree that the item is clearly measuring that objective. A value of -1 for this "valid" objective would indicate that the experts believe the item was not defined to measure. The value of 0.50 would know that at a minimum, and value of 1 is "good". Item reliability was assessed by using the draft scale in a pilot study with a sample of 30 farmers who were planting vegetables for trade in Nong Ruea district, Khon Kaen Province. Reliability of items in the Attitude item pool was assessed as 0.818 using Cronbach's Alpha coefficient. Reliability of the Knowledge items was found to be 0.776 using Kuder Richardson coefficient formula 20, or KR-20[17]. A widely accepted criterion is that tests with reliability index higher than 0.7 are reliable for group measurement[18].

Third, factor analysis: an exploratory factor analysis (EFA)[19], was carried out on data from the pilot study to identify factors and should therefore be included in the final readiness to change scale. Factors analysis carried out in six main steps: beginning in reliable measurement steps, based on, variables should be measured (at least) at an interval level, normally distributed and the sample size is adequate check by the Kaiser-Meyer-Olkin (KMO-test) is greater than 0.5. Correlation matrix steps: the intercorrelation can be checked by using Bartlett's test of spherity, which "tests the null hypothesis that the original correlation matrix is an identity matrix". This test has to be significant: when the correlation matrix is an identity matrix, there would be no correlations between the variables. Multicollinearity, then, can be detected via the determinant of the correlation matrix, if the determinant is greater than 0.00001, then there is no multicollinearity. Exploratory factor analysis steps: the eigen values will be determined and the factors will be extracted. Number of factors to be retained steps: based on, eigen value larger than 1 (Guttman-Kaiser rule), account for about 70-80% of the variance. Factors rotation steps: using orthogonal rotation with varimax rotaion. Factor loadings and factor scores steps: only factor loading with an absolute value greater than 0.4 (which explain around 16% of variance)[20], the author considered acceptable for the items with factor loading values of 0.5 were retention in the scale. Items lower than this, were cut out of the scale, making the item pool shorter and optimizing practicality of scale length and using SPSS version 13 for windows for this analysis.

Forth, Readiness to change score: theory of diffusion of innovation (DOI)[8] was used as a guideline for categorizing the farmers into two majors groups: cut off point of the readiness based on the scale score, high scale score group suggested readiness to change and low scale score group those who did not bear readiness to change.

Ethical review

This research proposal was reviewed and approved by the Human Research Ethics Committee of

Khon Kaen University (HE 531347).

Results

The first phase: the study of related factors to safe use of pesticides

Results from literature reviews provided a framework in creating a list of questions to be used in focus group discussions and in-depth interviews. These two methods were used as the qualitative approach of the study. It was found that factors relating to changing behaviors to safe use of pesticides consisted of four aspects as follows: the first aspect was concerning health. It included farmers' perception towards information on poisonous pesticides effecting health of both the farmers and consumers. The second aspect was concerning knowledge, this covered farmers' knowledge on how to use pesticides safely. The third aspect was concerning economics, it meant farmers' income from the residue-free vegetables for market sale or the security of their income. The fourth aspect was related to social dimension, this included farmers' acquisition of supports from various organizations to encourage behavioral change.

The second phase: the development of the readiness scale

This included steps as follows.

1) The creation of items in the readiness scale: factors obtained from the study in the first phase were used to create items in the readiness scale. Structures of the items were established from the factors relating to safe use of pesticides. The items targeted to test knowledge were containing questions that could point out farmers' knowledge on safe use of pesticides and risk of pesticides towards health. According to this stage, there were two main items (nine sub-items). As for the aspect of attitudes, there were 20 main items to measure determination towards safe use of pesticides and benefits from the practice. As for the aspect of practice, there were 11 main items measuring self-protective behaviors from pesticides' poisons and reduction and abandonment of pesticide use in planting vegetables. The items altogether consisted of 33 main item pools (with 40 sub-items).

2) The evaluation of the scale quality: the first draft of the readiness scale was evaluated by three experts using the item objective congruency index (IOC). It was found that the IOC was very good. The scale was tried out on 30 farmers; it revealed that the variable measuring knowledge showed Conbrach's coefficient at 0.776, and the variable measuring attitude showed Conbrach's coefficient at 0.818. Language used in the scale was also edited according to the lessons learned from the try-out.

3) The factor analysis: the obtained results were used as the exploratory factor analysis, or EFA. It showed a primary agreement of the factor analysis; that was that the variables and the items must agree. Results of the two statistic analyses included: 1) Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.822, which meant that the variables were reliable to measurement and appropriate for the factor analysis, and 2) Bartletts test of sphericity, which was used to test whether the items and variables had relations. As for the Bartletts test of sphericity, there was a hypothesis that H0 as an identity matrix, meaning that the variables had no relations. As for H1 as a non-identity matrix or it meant that the variables had a relation. The statistics from Bartletts test of sphericity was significant (χ^2 = 2,601.318, p<0.05) meaning that this correlation matrix was different from the identity matrix with the statistical significance (p<0.05). The results from both statistics showed that the variables had a strong relation and were appropriate for the factor analysis.

Results of the principal component analysis, or PCA, and the rotation sums of Orthogonal with Varimax, and the extraction sums of squared loading and the rotation sums of squared loading enabled the items with the high relationship to gather in one group. This also initiated nine new factors. Criteria used to sort out the factors were the usage of the sum of a quadratic equation of every single observable factor on one factor (Eigen values), the values that were more than 1 or the variation of each factor that could be explained with every single observable factor (the items). The first factor can be explained by variation of the data at 6.77, which was equivalent to 20.38%. The Eigen values in the followed factors would gradually decrease to 1.017 in the nine factors. In addition, all nine factors would explain the cumulative percentage of total variation as a whole at 61.42%.

The nine factors were the factors of the safe use of pesticides. Meanings of each factor reflected details gathered in each item. The item pool that clearly communicated the real meanings of the factors obtained another eight factors, the first to eighth factor. As for the ninth factor, the item pool did not clearly describe the meanings; therefore, it was determined to have only eight studied factors, which could explain all of the variations at 58.341%. The descriptions are shown in Table 1.

4) The appropriate cutting points: when testing the data distribution in the readiness scale, there found negative skewed distribution (p-value = 0.002). Therefore, median of scores in the readiness scale was used in the testing, which was 118 scores. This was used to divide the data into two groups. The highest score was 145 while the lowest was 58. Thus, 110 farmers were in the group that bore readiness to change behaviors. This group obtained higher scores than that of the median, meaning that the obtained scores were more than 118 (between the scores of 119-145), which was 48.0%. This showed that the group bore readiness to change behaviors. On the other hand, there were 120 farmers who were in the group that did not bear readiness to change behaviors. This group obtained lower scores than that of the median (between the scores of 58-118), which was 52.0%. The details were shown in Table 3.

Discussion

The results from the first phase of the study showed that behaviors relating to the safe use of pesticides obtained from the related studies and the qualitative method consisted of various factors including health, knowledge, economic, and social. This agreed with the result from studies of Pinthong[21]

Table 1. Cumulative percentage of total variation from the extraction sums of squared loading

Factor	Extraction sums of squared loading		
	Eigen values	Percentage of variance	Cumulative %
1	6.711	20.337	20.337
2	3.478	10.540	30.877
3	2.499	7.422	38.299
4	1.622	4.917	43.216
5	1.457	4.415	47.631
6	1.269	3.847	51.477
7	1.175	3.559	55.037
8	1.090	3.304	58.341
	Cumulative percentage of total variation		58.341

Table 2. Factors of readiness in changing behaviors of using pesticides of farmers

Factors	Percentage of variance (% of variance)	Eigen values
1) Social	6.711	20.377
2) Personal protection	3.487	10.540
3) Confidence	2.449	7.422
4) Eagerness to learn	1.662	4.917
5) Risk perception	4415	1.457
6) Practice	3.848	1.269
7) Knowledge of toxicity	3.559	1.175
8) Economic	3.304	1.090

Table 3. The categorization according to levels of readiness to change behaviors

Readiness of change	Readiness to change score	Amount/(percentage)
Ready	119-145	110 (48.0)
Not ready	58-118	120 (52.0)

stating that factors from planting pesticide-free vegetables were originated supports by outside institutions including knowledge exchanges, trainings, seminars, study trips, and current market that welcomed pesticide-free vegetables. Srikittikul[22] found that farmers accepted the planting pesticide-free vegetables when they were involved with a group working, earned their income, and positive attitude towards health. According to Forget[23], it showed that factors that exposed farmers to pesticide poisons were the lack of knowledge and information on chemicals, the lack of knowledge on effects of pesticides towards health as well as routes of entry of pesticides toxin into the body[24]. Factors that encouraged the changing of behaviors were that farmers paid attention to effects towards environment and that they had experienced on health problems due to chemicals[25]. When the factors were used as a guideline in creating items in the readiness scale, it was confident that the created items followed the framework of the targeted behaviors.

The second phase of the study discovered two main findings. The first one revealed that results from the factor analysis reduced the number of items. The items were recombined to make eight readiness factors were divided by the factors from the first phase of the study. The obtained information clearly reflected features of the behaviors, which was an advantage in applying such factors in intervention or creation of curriculum to changing behaviors properly. This also matched with the current condition of behaviors. For instance, results from the readiness scale reflected that when farmers lacked factors, they would create changing processes matched with the missing factors. This also increased confidence that developmental programs would potentially achieve efficiency in changing farmers' behaviors related to safe use of pesticides. In addition, the eight factors used as predictions in identifying farmers who are ready to change, the factors used as predictors are not the only ones that could be relative to readiness and so maybe other factors could account for readiness.

The second finding, the results of the study were consistent to various theories of changing behaviors, for instance, the theory proposed by Prochaska and Di Clemente[26]. It was stated that human beings are changing their behaviors due to increasing of perception to new behaviors, for instance, feeding information, providing education, receiving social supports, and that individuals chose beneficial behaviors instead of continuing harmful practices. These matters also agreed with the social support theory[27] stating that when individuals received informative assistance, materials, or moral support from others, the receivers would practice or express their behaviors in a way that the givers wanted.

All of the eight factors provided insights on how to implement a behavioral change program. For example, providing only knowledge was not enough to solve problems concretely related to the behavior of using pesticides. In a study using health belief model to identify risk perception from using pesticides on health, the findings showed that farmers posed risk perception at a higher level after learning about safe use of pesticides, however, their pesticide-use behaviors did not change[28]. Therefore, designing an intervention to change effectively pesticide-use behaviors, must include factors identified in this study.

The content validity was established by development from the literature reviews and the qualitative data, assessment by three experts using IOC procedure and measuring with exploratory factor analysis. However, additional further measuring is necessary to determine whether this scale can identify contrasting groups, i.e. high versus low readiness to change behavior required for measuring construct validity by using confirmatory factor analysis.

There are also limitations associated with the development the readiness scales. First, this study had no gold standard for judgement of pesticides use, safety behaviors. Therefore, the application of theories to create the cut-off point of readiness scale based on scale score and this scale represents only one way to evaluate the readiness of behavior change in farmers. Second, the sample size was inadequate (n = 230) for separate analysis of samples which may be the best means of demonstrating its generalizability. Third, limitations for confirmatory factor analysis, because confirmatory factor analysis uses of large sample size in application. Fourth, the first draft of questionnaire is somewhat long (40 items) for testing in a group of farmers. Finally, the questions of external validity, for example, in terms of the setting in the farmers' cultivation for market sale were inappropriate for generalize application to other groups of farmers. These limitations are all important topics for future research on developing an instrument, in particular, the readiness scale.

Conclusion

The development of the readiness scale was initiated from using desirable characteristics of the theory of changing behaviors as a guideline. Factor analysis is an essential tool in scale development, to determine number of factors underlying a set of items. Especially using them to analyze complicated, difficult-to-test behaviors, which had no gold standard.

The readiness scale was used to recruit qualified farmers or the farmers must be ready to enter the development process to change behaviors. It minimized the size of the amount of dropout while operating the development activities. Therefore, the efficiency of the development was increased in order that it was primarily screened for their readiness to learn new information, knowledge, and various processes. Moreover, the details of the tested factors could be used as a guideline in suitable intervention for the farmers later.

What is already known on this topic?

Pesticide is well recognized as chemical solution contaminated in food, particularly in cash crop economy. Thailand increasingly imported pesticide each year. The government convinced the farmers to change their pesticide use behaviors through various strategies. It is evident that the farmers are not ready to change their own behavior regarding pesticide use.

What this study adds?

This study develop a screening test to examine whether the farmer is ready to change their behavior regarding pesticide use. The scale developed could be used to screen the farmers before introducing intervention to change behavior regarding pesticide use.

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Potential conflicts of interest

None.

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การพัฒนาแบบวัดความพร้อมในการปรับเปลี่ยนพฤติกรรมการใช้สารเคมีกำจัดศัตรูพืชของเกษตรกร

ดวงใจ วิชัย, ปัตพงษ์ เกตุสมบูรณ์, จอห์น สมิท

ภูมิหลังและวัตถุประสงค์: *พฤติกรรมที่ไม่เหมาะสมการใช้สารกำจัดศัตรูพืชกำหนดผลกระทบทางลบอย่างมีนัยสำคัญต่อสุขภาพและสิ่งแวดล้อม โปรแกรมพัฒนาการการเปลี่ยนแปลงพฤติกรรมดังกล่าวของเกษตรกร ควรกำหนดเป้าหมายผู้ที่มีความพร้อมที่จะเปลี่ยนแปลงเพื่อให้เกิดประสิทธิภาพ การศึกษานี้มีวัตถุประสงค์เพื่อพัฒนาแบบวัดความพร้อม ในการปรับเปลี่ยนพฤติกรรมการใช้สารเคมีกำจัดศัตรูพืชของเกษตรกรนำไปใช้ในการคัดเกษตรกรเข้าสู่กระบวนการพัฒนาโปรแกรม*

วัสดุและวิธีการ: *การศึกษาแบบตัดขวาง (cross-sectional study) แบ่งออกเป็น 2 ขั้นตอน ขั้นตอนแรกวิธีการดำเนินการในเชิงคุณภาพ เกษตรกรผู้เข้าร่วมจำนวน 17 คน ในการหาปัจจัยที่เกี่ยวข้องกับความปลอดภัย ในการใช้สารกำจัดศัตรูพืชของเกษตรกร ขั้นตอนที่สองวิธีการเชิงปริมาณในการพัฒนาแบบวัดความพร้อม ใช้การวิเคราะห์ exploratory factor analysis (EFA) ในเกษตรกร 230 คน โดยการสุ่มในการวัดความตรงเชิงโครงสร้าง (construct validity) ความสอดคล้องภายใน (reliability), unidimensional และจุดตัดที่เหมาะสมตามลำดับ*

ผลการศึกษา: *เกษตรกรใช้สารกำจัดศัตรูพืชพฤติกรรมความปลอดภัยที่เกี่ยวข้องกับปัจจัยหลายประการ และนำไปใช้สร้างชุดของคำถามของแบบวัดความพร้อมได้ 33 รายการหลัก (มี 40 รายการย่อย) การวิเคราะห์ ปัจจัยที่ระบุ 8 โดเมน ซึ่งการทำนายที่ดีที่สุดในการระบุเกษตรกรที่มีความพร้อมที่จะเปลี่ยนแปลง สุดท้ายได้ 23 คำถามหลักที่มีคำถาม 30 ข้อย่อย*

สรุป: *การพัฒนาแบบวัดความพร้อมใช้ทฤษฎีพฤติกรรมที่เปลี่ยนแปลงเป็นแนวทาง การทดสอบความถูกต้องที่ใช้ดัชนี IOC การวิเคราะห์ปัจจัยเชิงสำรวจในการจัดกลุ่มข้อคำถามและความน่าเชื่อถือของแบบวัด แบบวัดนี้สามารถใช้ในการคัดเกษตรกรเข้าสู่โปรแกรมการพัฒนาในการเปลี่ยนแปลงพฤติกรรมการใช้สารกำจัดศัตรูพืชได้*