Understanding Pesticide Use Safety Decisions: Application of Health Behavior Theory

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Abstract: Pesticide associated health effects are serious public concerns in Pakistan. Therefore, understanding of farmer’s risk perception and safety behavior is important for appropriate policy interventions. This study sought help from social psychology to explain farmer’s safety behavior. Referencing Health Belief Model from social psychology, it examined “whether or not adverse health experiences play a part in shaping farmer’s attitude and safety behavior”. The research has exhibited a strong support for the hypothesis. The results of the study indicated that there is significant positive relationship between health effects experienced by the farmers due to the pesticide exposure and their risk perception toward the seriousness of health effects. Moreover, a strong positive relationship was also found between hazardous health experiences from pesticides and the use of safety measures. This implies that to improve awareness, specific and relevant information regarding the health and environmental risks of using pesticide should be provided to farmers through various training programs. The government must design effective outreach programs through farmer field schools, electronic and print media unleashing the health risk of pesticide use, averting behavior and better management of pesticides.

Key words: Pesticide use • Health Belief Model • Safety behavior • Health effects

INTRODUCTION

The synthetic pesticides are an integral part of present day farming in Pakistan. Indeed, they have significant contribution in the improvement of crop yield by killing pests which may otherwise inflict huge damages to crops and in some cases destroy whole crops [1]. However, this role of pesticides is linked with disutility that results in negative externalities [2, 3, 4] which may include effects on human health, loss of bio-diversity, degradation of natural ecosystems and irreversible changes in the environment. Various kinds of pesticides have been used on a large scale to protect crops from damages caused by insects and diseases since the early 1950s, in Pakistan. After liberalization policy of pesticides in 1980, their use increased dramatically in Pakistan. Pesticides use increased from 12530 metric tons in 1985 to 129598 metric tons in 2004. However, after 2004 this trend is decreasing and in 2010 the total consumption of pesticide is 73632 metric tons due to implementation of National IPM program and enforcing strict regulations by the government [4]. This huge increase in pesticide use is not translated into productivity improvements rather it affected human health enormously and degraded environment. The research [5] found that 1.08 million persons were affected by pesticides related sickness from which 24000 persons were admitted in hospitals while 271 fatalities took place in cotton growing areas of Punjab. Moreover, it is found that annual health and environmental cost of pesticide use in nine cotton growing districts of Punjab is about 11941 million Pak-rupees. In a recent research Khan has also found that more than 80% cotton farmers experienced health symptoms during spray in district Vehari and Lodhran. In another study, he reported that on an average a cotton grower is willing to pay Pakistan rupees 582 (about 6 US dollars) in a year in these district to avoid health risks of pesticide use [2, 4].
Like all other economic problems, decision making regarding pesticide associated health safety involves allocating scarce resources to meet individual needs. Concurrently, decision making is also concerned with the goals and behavior of those who make decision. Therefore, it is important to obtain information about farmers’ attitudes, perceptions and behaviors prior to develop research and safety programs [3]. The classical microeconomic consumer theory states that individuals make choices following their preferences. However, classical theory is poor in explaining and predicting consumer behavior and do not focus on the processes of individual’s reasoning behind choices. They also do not consider sociological and psychological factors that guide consumer behavior. In this regard, social psychology is more successful in interpreting these phenomena than is a plain economic model. Therefore, health communication research has recommended the application of cognitive psychological or behavioral models to understand individual decision making behavior.

Theories of cognitive psychology corroborate that risk understandings are developed through intuitive experiential and cognitive analytic systems at personal levels. Experiential or observed information is more meaningful to change behavior than abstract information. Furthermore, the literature in health psychology recommends the application of behavioral theory to explain the relationship between health experience and pesticide safety behavior [6].

The study used Health Belief Model (HBM) from health psychology and combines it with new classical microeconomic theory to demonstrate farmers reasoning of using or not using safety measures to avoid direct exposure of pesticide. The use of health psychology concepts leads to better interpretation of the phenomena and helps policy makers to reach better solutions of agriculture pollution and health safety in the country.

The major objectives of the study are:

- To examine the level of awareness and role of household characteristics in pesticide safety decisions.
- To evaluate the relationship between health effects, risk perceptions and safety behavior of the respondents in the study area.

**MATERIALS AND METHODS**

For the sake of data collection for the study, two districts i.e. district Vehari and district Lodhran were selected in the cotton growing areas of Punjab, Pakistan which are historically famous for cotton production and have a long history of pesticides use. Pesticides are intensively used on cotton (70-80%) [3]. Agriculture is a backbone of the economy of both the districts. The structured questionnaire was used to collect data from farmers. The survey was undertaken in 2008 and self-administered face to face interview method was adopted to collect information from the respondents. The study used a combination of purposive and probabilistic sampling. Purposive sampling method was used primarily because the lists of farmers using pesticide in study areas could not be found; actually were not available. To study a small subset of a larger population, the cluster sampling was used to collect data economically. Clusters were selected for their proximity to tehsil or district headquarters and availability of resident’s information which provides basis to make lists of farmers using pesticide in the selected areas. A random sample of 400 farmers was drawn without replacement using www.random.org/nform.html. Finally, 318 interviews were successfully completed in both districts.

**The Conceptual Framework:** Health Belief Model (HBM):

This model was developed in 1952 by Godfrey Hochbaum [7], when he started research to identify the factors that lead individuals to decide to have their examination for prior detection of Tuberculoses (TB). Over time the domain of this model has been extended to explain general as well as specific health motivation for health behavior [7, 8]. Basically, “Health Belief Model” encourages a person to adopt positive health actions using the desire to avoid illness as the key inspiration. For instance, in the current settings, pesticide exposure has negative health effects and the desire to avoid direct exposure from pesticide can be used to motivate farmers practicing safety measures for the safer use of pesticide. Broadly “Health Belief Model” is based on following key concepts:

- Perceived threat: It is further classified into two parts; perceived susceptibility and perceived severity;
- Perceived benefits;
- Perceived barriers;
Cues to action and
Modifying variables.

The Health Belief Model postulates that individuals’ behavior change is a function of individuals’ mental appraisal of the barriers and benefits of taking certain action [9]. If perceived health effects are serious and net benefits of taking action are positive, there is a more probability that individual will take action.

Health Belief Model (HBM) and Pesticide Use Behavior:
This study selected the health belief model to gain better understanding of relationships between health experience, risk perception and pesticide use behavior. This health belief model has been chosen for the present study because of several reasons:

- It considers individual as an active information processor and independent decision maker. Since pesticide use is largely governed by voluntary behavior, hence health belief model best suits in present target research;
- Another advantage of HBM is its simplicity that makes it attractive to understand health behavior. Despite the fact that HBM describes the framework in which each individual variable contributes in the prediction of health behavior [10, 11], but it does not follow strict guidelines like other models of health psychology to predict health behavior. Although this lake of proper guidelines is considered as shortcomings of this model which is a cause of heavy criticism on it. Concurrently, the flexibility of the construct makes this model very attractive among researchers and that is why it is the most frequently used model in health psychology.
- It is pronounced fact that HBM is a health-specific model but it also allows socio-economic variables to be included in the model which affect health motivation. Because of the aforementioned features discussed, the HBM has won much wider support from practitioners, academia and researchers [9].

A major problem that emerged out of the HBM framework is that it largely lacks accepted scale. Therefore, different researchers adopted scales on their own and used different research questions to illustrate the same risk perception. Consequently, it made very difficult to compare different studies and to identify most appropriate scales of the HBM [8]. The present study has adopted more direct approach to apply HBM in the context of farmer’s health behavior which avoids many of such problems. Instead of using a respondent’s perceived susceptibility, following Lichtenberg and Zimmerman [12] this study uses actual negative health experience associated with pesticide use which is a more direct measure of health risk relative to perceived health risk. The susceptibility component of health belief model is the closest “analogous to the health experiences that farmers have reported in connection with pesticide” [12]. The actual experience of health problem heightens individual’s perceptions regarding health threats. The individual’s heightened perceptions regarding health threats may or may not motivate farmers to change their behavior with respect to pesticide use and safety [12]. The conceptual framework used in the present study is depicted in Fig. 2.

Based on conceptual understanding, a model of pesticide safety behavior has been established. This model links farmer’s adverse health experiences and risk perceptions to the safety behavior of pesticide use which has been discussed in detail in the following section.

The Model of Health Experience, Risk Perceptions and Pesticide Safety Behavior: Pesticides are by nature a poison and therefore, are likely to impair health of the farmers. There is a close interdependence between farm and farm workers. Therefore, the negative health status of the farmer can significantly affect farm production and overall welfare of farm households. One of the efforts by the farmers to protect themselves from direct exposure of pesticide use e.g. improve pesticide practices and reduce potential health effects of chemical use is to undertake safety measures. However, the decision to use safety measures depends on cost (barriers; e.g. monetary cost of safety measures and cost of discomfort) which require less use of safety measures and benefits (improved health) which requires higher use of safety measures. A farmer will use safety measures only if he believes that he will be better off by doing so. Analogously, a farmer will use safety measures only if he believes that positive health benefits of using safety measures (perceived benefits) are greater than the cost (perceived cost) of using safety measures.

At the same time, the decision to use safety measures is determined by the level of awareness and quality of information. If information gap exists, health costs of pesticide use are most likely not to be included in decision-making which may result in sub-optimal choices.
If a farm worker is aware of the health consequences of pesticide use on overall household welfare, he/she would choose to use more safety clothing while using pesticides. Thus, the accuracy of information and knowledge of farmers regarding pesticide safety are key issues in pesticide safety decision making behavior.

In studying how farmers react to information about pesticide's associated health effects, this section builds an empirical model that link farmer’s adverse health operationalized in following empirical model:

$$RP = g(HE, Z) + \xi, \quad (1)$$

$$SB = h(RP, Z) + \xi, \quad (2)$$

$$Actual health experiences \rightarrow \text{Heightened risk perception} \rightarrow \text{Likelihood of action}$$

$$\begin{align*}
\text{Cues to action} & = \text{Mass media Campaigns, Advice from others, Environmental damage (e.g. death of fish, frog, and birds), Pesticide label, Printed material} \\
\text{Demographic & socioeconomic Variables:} & \text{ (Age, Sex, Personality, Knowledge about the disease, socioeconomic variable, etc). Mass media campaigns, Advice from others, Environmental damage (e.g. death of fish, frog, and birds)}
\end{align*}$$

$\text{Modifying Factors}$

Perceived benefits of preventive action minus perceived barriers to preventive action

$\text{Likelihood of taking recommended Preventive health action}$

Source: Strecher and Rosenstock (1997)

Fig. 1: Health belief model

Fig. 2: Relationship between health experiences, risk perception and pesticide use behavior
where RP represents farmer’s perception of pesticide associated health risk, HE represents health effects experienced by farmers due to pesticide exposure, Z represents vectors of variables included in the equation to measure farmers risk perception. Moreover, SB defines the safety behavior while î represents random errors.

The disturbances of error terms are such that covariance of (ξ, ξi) is zero.

\[ \text{Cov}(\xi, \xi_i) = 0 \] (3)

That is, the same period disturbances across equations are not correlated. The right hand side of the equation (1) contains only explanatory variables and “by assumption these variables are not correlated with the error term ξi. The equation (1) fulfills the important assumption of no correlation between the independent variables and the stochastic disturbance terms” [14]. The same stance is true for the second equation because RP is uncorrelated with ξi. Actually, we do not have simultaneous equation problem in this situation. It is clear from the structure of the system that there is no interdependence among the endogenous variables. Thus RP affects SB but SB does not affect RP. RP equation exhibits unilateral causal dependence, hence one can proceed with the estimation of single equation separately [14]. Returning back to model, it is assumed that risk perception of pesticide can be determined by variety of factors like health effects experienced by farmers, the level of education and pesticide handling training [15]. Hence equation (1) assumes that farmers formulate their perception from available information and demographic characteristics. Thus, it is rewritten as:

Risk Perception = f (health experiences, age, education, training, district dummy) + ξi

(4)

The equation (2) is rewritten as:

Safety behavior = f (health experiences, risk perception, age, education, training, income, district dummy) + ξi

(5)

The dependent variables in both equations “risk perception” and “safe behavior” are multiple response variables that they demonstrate an intrinsic order. Therefore, one must look for “ordered qualitative response models” to analyze above equations. Two broad choices, the logistic or standard normal density functions, are readily available. If \( \Phi(\cdot) \) is the logistic density, then the ordered logit is the resulting probability model; if \( \Phi(\cdot) \) is the standard normal density, the ordered probit is the resulting probability model. As both densities are symmetric the results obtained from the two models are similar. To model health experience and farmer’s behavior, an ordered probit model is preferred over order logit. An ordered probit was preferred over others because it allows researcher to calculate predicted probabilities and marginal effects directly [16]. Marginal effects explain the change in predicted probability due to a change in explanatory variable. The framework used in the study as follows:

\[ \hat{Y} = x'\beta + e | x \sim \text{Normal} (0, 1) \] (6)

where \( \hat{Y} \) = the latent (or unobserved) variable, \( X \) = vector of explanatory variables, \( \beta \) = vector of parameters and \( e \) = independently and identically distributed error term with mean zero and variance one [17].

RESULTS AND DISCUSSION

Empirical Analysis of Health Experience and Farmer’s Attitudes: In this section, a hypothesis that links pesticide associated health experiences with farmer’s attitudes has been statistically tested. Specifically, it is assumed that those farmers who experienced any negative health effect while pesticide application were expected to have heightened concerns about health risk associated with pesticide use [12]. This hypothesis was important because more than 90% farmers in district Lodhran and about 80% farmers in district Vehari experienced health effects while using pesticides. To test this hypothesis risk perception was regressed with independent variables like health experience, age, education, training, income, farm size and geographical area.

The estimated coefficients of ordered probit are presented in Table 1. The estimated model has a Pseudo R² about 0.1302. The null hypothesis which explicitly assumes that all the coefficients in the model are jointly equal to zero is rejected at 1% level. The results of the ordered probit model are in line with most of the assumptions/expectation. As expected, the results proved that the farmer’s who experienced any health effect while using pesticides, had positive association with risk perception. The result also shows that this association is very strong and significant. This result is very much
Table 1: Ordered probit results for risk perception

<table>
<thead>
<tr>
<th>Variable</th>
<th>Risk perception</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education</td>
<td>0.0669755*** (4.74)</td>
</tr>
<tr>
<td>Age</td>
<td>-0.0029556 (-0.46)</td>
</tr>
<tr>
<td>Income</td>
<td>0.0403085* (4.30)</td>
</tr>
<tr>
<td>Health effects</td>
<td>0.827102*** (5.17)</td>
</tr>
<tr>
<td>Farm size</td>
<td>-0.0042312** (-2.03)</td>
</tr>
<tr>
<td>District Dummy(Vehari)</td>
<td>0.422231*** (3.42)</td>
</tr>
</tbody>
</table>

Log likelihood = -426.70839, Pseudo R2 = 0.0895, LR chi2 (12) = 83.88***

Note: Z-scores in parenthesis, * - significant at the 10% level, ** - significant at the 5% level, *** - significant at the 1% level.

Table 2: Results of ordered probit regression for safety behavior.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Safety behavior</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health Effect</td>
<td>0.6161179 (0.001)</td>
</tr>
<tr>
<td>Risk perception</td>
<td>0.1402597 (0.037)</td>
</tr>
<tr>
<td>Age</td>
<td>0.1077838 (0.103)</td>
</tr>
<tr>
<td>Education</td>
<td>0.1421597 (0.000)</td>
</tr>
<tr>
<td>Training</td>
<td>0.8986106 (0.000)</td>
</tr>
<tr>
<td>Income</td>
<td>-0.1684239 (0.047)</td>
</tr>
<tr>
<td>District Dummy</td>
<td>-0.028836 (0.823)</td>
</tr>
<tr>
<td>Farm size</td>
<td>0.0579337 (0.464)</td>
</tr>
</tbody>
</table>

The values in parenthesis are P values. Log likelihood = -373.34005, Pseudo R2 = 0.0920, LR chi2 (12) = 75.62 (0.000)

Almost all the results are analogous to prior expectations except farm size and age. Both farm size and age of the farmers are negative to risk perception. This might be due to the fact that the large land holders are likely to use more safety measures, face less health effects and perceive less health risk of pesticide use. Moreover, it is also assumed that large farmers do not apply pesticides by themselves regularly and usually get this job done by hired labor. As far as interpretation for age variable is concerned, over time farmers are used to of the health problems/illnesses that are associated with pesticide spraying. They may take them a routine matter and do not take these effects very serious and hence usually ignore them. It seems true, because many farmers believe that these health effects are routine matter. This compartment may well explain the lack of pesticide related health awareness and the analogous reasoning was explained by [18, 2]. Unfortunately, as per empirical analysis of the study this relationship is not significant. Nevertheless, the variables like health impairment, farmer’s education, as well as income are statistically important variable to explain the variation in farmer’s perception of pesticide risk (Table 1).

Empirical Analysis of Health Experience, Risk Perception and Safety Behavior: The behavioral factor studied here is the extent to which farmers used safety measures to avoid pesticide exposure when they believe that they have experienced negative health effects from pesticides. However, results show that farmers who experienced health symptoms during mixing or spraying pesticide are more likely to adopt safety measures in ceteris paribus scenario. Moreover, the findings support the hypothesis that there is a strong linkage between adverse health effects and safety behavior. Seriousness of health risk is important factor in shaping individual’s behavior. As per results of the study, individual’s risk perception appeared as an important factor to convince farmers to take more protection which is in line with previous literature and theoretical background. This evidence suggests that pesticide associated negative health problems act as a signal to change farmer’s future behavior toward pesticide safety. The result is consistent with theory and expectations.

It is widely accepted that education enhances awareness regarding health that is clear from Table 2. The more educated farmers reported taking more safety clothing than farmers with less education. The result implies that education exerts a significant effect on the decision to adopt safety measures. The farmers who got
training of safe pesticide handling reported significantly higher concern about protection. This could be interpreted as indicating that the more learned farmers in terms of safety are more likely to select higher level of protection than non-trained farmers. Similar findings were observed by Lichtenberg and Zimmerman [12]. District controls reveal that protection level to avoid direct exposure from pesticide is not significantly different in both districts. However, it is important to note that although farmers in district Vehari relative to farmers of district Lodhran are more educated but they are less likely to use protection. The result may indicate that negative health effects have stronger impact on averting attitude of farmers than their education. The result follows ‘Health Belief Model’ which states that actual experience of adverse health effects (concrete information) have stronger impact on individual’s coping behavior than general pool of knowledge (abstract information/education).

The negative relationship between income and safety measures is the harshest which is surprising and can’t be explained properly. Results do not provide any evidence of statistical association between the age of farmers and level of protection. Again same arguments can be presented that with farming experience farmers are ready to accept certain level of health effects and they consider them a routine matter. Therefore, their risk perception is low and they are less likely to take safety measures. Similarly no significant relationship was found between farm size and level of protection in the study area. Overall, results indicate that farmers who have had health experiences do care about the effects of pesticide application and do engage in safety practices.

In summary, we observe that the results supported the hypothesis that farmers who have had negative health experience related to pesticide use are more likely to heightened perception than the farmers who have not such experience. The results also support the hypothesis that there is a strong linkage between adverse health effects and safety behavior. Seriousness of health risk is important factor in shaping individual’s behavior. As expected, individual’s risk perception appeared as an important factor to convince farmer to take more protection. Moreover, both training of safe use of pesticides and education have strong influence on farmer’s averting behavior.

CONCLUSION AND POLICY IMPLICATIONS

The indiscriminate use of pesticide leads to both direct and indirect costs in terms of health and environment. The evidences from cotton growing areas have indicated that health impairments of farm workers and environmental damage are mounting because of growing dependence on pesticide use. Since farmers are principal polluter and victim of the pollution, it is important to understand their risk perception and behavior. The information regarding farmer’s behavior is critical to identify the prospects and constraints to the adoption of better crop protection policy. This study combines health belief model from social psychology with new classical theory to better explain farmer’s pesticide safety behavior.

The analysis supported the hypothesis that farmers who have had negative health experience related to pesticide use are more likely to have heightened risk perception than farmers who have not experienced such health problems. Education and training are also important determinant of risk perception. The findings also support the hypothesis that there is a strong linkage between adverse health effects and safety behavior. Seriousness of health risk is important factor in shaping individual’s behavior. Again education and training appeared as an important determinant of safety behavior.

It must be noted that ill health and environmental effects caused by indiscriminate use of pesticide are severe. Moreover, these externalities are affecting a large share of the farming community in study area and there exist solutions that can contribute significantly in the improvement the health of farmers as well as the environment. Based on this research results, these areas should receive priority attention.

The study recognizes that education is a powerful tool for improving farmer’s awareness regarding pesticide related health and environmental problem. The finding that education is positively and significantly related to farmers’ risk perception and behavior toward adopting safety measures offers important policy implication. It implies that innovative and practical educational programs on health and safety would facilitate farmer’s understanding of pesticide borne health risks. The continuous stress on the basic safety measures would be an immediate solution to dangerous spray practices and wrong habits which put farmer’s health at jeopardy. Therefore, one of the corner stone of this research is that the public resources diverted to provide information regarding health and safety related issues are effective even if enforcement of laws regarding pesticides and public investment for more comprehensive and detailed intervention is missing. Government requires strengthening information that is provided by the agriculture extension for plant protection. The government may also engage other stakeholders in this process.
Endnotes:

- This model states that individual’s perceived threat of disease is influenced by the perceived seriousness of and susceptibility to a disease. Likewise, perceptions about the health behavior are influenced by perceived benefits and perceived barriers. Thus, both demographic and socio-psychological variables can affect perceived susceptibility as well as perceived seriousness. It is also found that the likelihood of engaging in the recommended behavior is escalated by high-perceived threat, low barriers and high perceived benefits to action [10].
- The model comprises a series of broadly defined constructs that might explain the variance in health behavior but there are no clear operational guidelines regarding relationships between them.
- Most health belief model based research to date has incorporated only selected component of HBM [9].
- The use of protective measures in hot and humid climate makes farmers uneasy.
- The knowledge about health effects, the risk perception and the importance that farmers attach to health issues are important determinants of safety behavior.
- Perceptions are an individual’s subjective mental construct which is vibrant and active in nature and over time can change considerably [13].
- Overhauling of current extension services is needed that can be achieved by improving their knowledge about the changing trends of pest populations.
- These interventions include media programs, seminar by NGOs and community for the promotion of awareness about risk issues. It can further include social institutions such as community leaders to improve farmer’s knowledge about risk that may result in change in knowledge, attitudes and behaviors.

It must be noted that education alone is not enough to address this issue. To improve the degree of success, training of safe and better pest management practices is also necessary. An opportunity to integrate IPM training technology into current crop protection methods is provided by the results that reveal the strong correlation among heightened risk perception, IPM training and safe behavior of pesticide use. Many studies [2, 4, 5, 3] that were conducted in the sample area support the feasibility of the IPM technology. There is a need to develop and provide safety equipments feasible to the hot and humid climate of Pakistan. These should also be affordable and accessible for the average farmer.

REFERENCES


