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PROPENSITY SCORE MATCHING METHOD TO ESTIMATE IMPACT OF VIETGAP PROGRAM ON HEALTH OF FARMERS IN THUA THIEN HUE PROVINCE, VIETNAM

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Abstract: This study estimates the impact of the VietGAP program on the health of farmers producing vegetables in Thua Thien Hue province. By employing the propensity score matching (PSM) method, we found that the VietGAP program has a significant impact on farmers' health. Specifically, the program reduces farmers' health problems due to pesticide exposure by 15.6 %, 22.9 %, 25.5 %, and 23.6 % in four types of matching. This study provides evidence of the positive impacts of the VietGAP program on the health status of the farmers in Thua Thien Hue province. It is, therefore, hoped that the production, consumption, and management solutions provided by the VietGAP program can encourage farmers to use environment-friendly agricultural practices.

Keywords: propensity score matching, VietGAP program, farmers' health

1 Introduction

Exposure to pesticides is an occupational hazard for farmers in developing countries. According to FAO (2010), there is a high incidence of contamination and poisoning in crop farmers due to pesticide use. The severity of each hazard depends on the toxicity of the pesticide, the means of exposure, and the extent of the exposure (Hashmi and Dilshad, 2011). Different families of chemicals cause different types of symptoms, and individuals vary in their sensitivity to each level of chemicals. In general, short-term exposure to high doses of pesticides can cause skin, eye, nose, and throat irritation; difficulty in breathing; impaired lung function; delayed response to a visual stimulus; headaches; impaired memory; stomach discomfort; fever; muscle weakness; and possible changes in the liver and/or kidneys. Both short- and long-term exposures can potentially affect the nervous system (Hashmi and Dilshad, 2011).

From 2011 to 2015, there were 843 cases of food poisoning in Vietnam with 22,373 affected people; 116 of which died (Food Safety Division, Health Ministry 2015). In 2012, an investigation conducted by the Institute of Policy and Strategy for Agriculture and Rural Development proved that out of the 1,050 samples of three types of vegetable collected from eight provinces, 51 % contained residues of plant protection chemicals and heavy metals. Prolonged exposure to pesticides can negatively affect the health of Vietnam's populace. Accordingly, because farmers deal with pesticides in their work, this negative impact on their health can manifest itself to a disproportionate degree within farming communities.

Unregulated and excessive use of pesticides has compounded the hazards associated with pesticide use (Hashmi and Dilshad, 2011) although pesticide risk reduction and risk

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management play an essential role in agricultural practice (FAO, 2010). In developing countries, the low levels of education in the rural areas, limited information on and training in pesticide safety, poor quality of protective equipment, and inadequate precautionary equipment increase the potential for harm (Hurtig et al. 2003; Atreya, 2008). Therefore, the government should focus on raising farmers' awareness of the negative health effects of unsafe pesticide use and on promoting the importance of communication and education programs that aim to reduce health risks. In addition, environment-friendly agricultural practices should be introduced and expanded in order to encourage greater public health and food safety.

The Vietnamese government has made every effort to introduce and conduct national policies and regional pilot programs to encourage communities to produce safe vegetables and environment-friendly food. VietGAP (Vietnamese Good Agricultural Practice) is one such implementation program; it aims to create and change producers' and consumers' behaviors (MARD, 2008). The production of safe vegetables has been publicly approved via a bias toward environment-friendly agricultural practices. It is then important to minimize the potential hazards of pesticides by lowering farmers' reliance on pesticides, by selecting pesticides with the lowest toxicity-risk to human health and the environment for use in crop production, and by properly using recommended products in accordance with international environment-friendly standards (FAO, 2010). In addition, the attitudes of famers who have been appropriately educated and trained play a crucial role in safe crop production. There is an increasing focus on the promotion of good agricultural practice (GAP) on farms, in agribusiness, and in the food industry. GAP provides an advanced approach to better production practices, and results in less environmental contamination during production and fewer pesticide residues in agricultural products (FAO, 2010). Production under GAP schemes and protocols offers an opportunity for farmers to better select and utilize pesticides within national and international quality standards. With the long-term incentives currently available, applying GAP could create sustainable benefits for farmers.

Thua Thien Hue province in Central Vietnam operates pilot programs in safe vegetable production. Since 2010, the VietGAP program in Quang Thanh commune (Quang Dien district) has been operating using the organizational framework, technical support, and initial financial approval of the Department of Science and Technology, the Department of Agriculture and Rural Development, the Agricultural Extension Center, and Hue University of Agriculture and Forestry. Safe vegetable production has been practiced by household participants, agricultural cooperatives, and small business enterprises using the VietGAP program. To date, VietGAP production has been widely expanded among farmers in Quang Thanh via training courses and under the technical supervision of local agricultural cooperatives. The production process has strict regulations throughout—from input management for seeds, fertilizers, and plan protection products, to harvest management and waste management. All participants have attended training courses that explain every step of the production process from intensive cultivation, disease prevention, chemical use, harvest and postharvest techniques, to waste management, information-sharing meetings, and field experiments. Household participants who pass the strict technical regulations required for safe vegetable production according to VietGAP procedure standards receive certification. Through technical training courses and agricultural extension, an increasing number of farming households have been engaged in VietGAP procedures.

VietGAP production is different from conventional farming practices in that the former adopts a different set of standards and uses different types of fertilizers and pesticides that are usually environmentally friendly. The production procedure must follow the technical criteria established by VietGAP in terms of input management for seeds, fertilizers, and plant protection products and in terms of harvest management and waste management (MARD, 2008). Producing certified vegetable crops also requires more labor and is subjected to stricter regulations than the production of traditional crops do. Agricultural cooperatives and local governance play important roles in introducing, assisting, and encouraging farming households to adopt VietGAP standards by helping farmers via the provision of agricultural services and technical consultancy (Provincial Department of Science and Technology, 2011).

In spite of the initial challenges with regard to market access, participation in the VietGAP program was approved for the purpose of community health protection. Farmers typically have inadequate information on the health impacts of pesticide use, which may discourage them from converting from conventional production techniques to certified safe production. Therefore, the health risks associated with pesticide use in conventional production need to be clarified via empirical evidence.

2 Literature review

Theoretically, adopting GAP provides health benefits as it would change farmers' pesticide use and hygienic practices (Asfaw, Mithöfer, and Waibel, 2009). However, although the health risks associated with pesticide use and their costs are now gradually becoming understood, the positive potential offered by the adoption of GAP standards has not yet been realized. This is because only a few studies have provided empirical evidence of the causal effects of GAP participation on farmers' health. It is widely recognized that the initial barriers of labor expense and technical requirements in new advanced production methods still have an impact on the decision to convert from conventional production to certified environment-friendly production (Uematsu and Mishra, 2011). However, once farmers learn and understand the health risks posed by using high doses of pesticides and the associated health impact value of this usage, they would become motivated to convert from conventional production to certified safe production.

This study primarily expects to contribute to the existing literature that presents empirical evidence on the health benefits that can be gained from the VietGAP program. Health concerns used to be identified as a motivation for safe vegetable production (Simmons and Scott, 2007), and some safe production programs have been implemented in Vietnam. However, some of the information on the estimated causal effects of these programs on the health attributes linked to the economic valuation of health impacts may be misleading. Rola and Pingali (1993) cited the impact of pesticide dosage on productivity in the production function in order to obtain the appropriate spray level of chemicals in crop production. Dung and Dung (2013) considered health impacts by valuing the economic health consequences of pesticide use in the paddy production of farmers in the Mekong Delta; the authors denoted the health factors associated with its use through the health impairment and health cost, given the pesticide dosage used in conventional paddy production. These studies were conducted in the context

that farmers mostly implement conventional production, in which farmers personally control the pesticide dosage applied. In other words, most of the recent empirical results measure the health impact value of the standardized production safety programs on farmers.

This study examined the farmers who have adopted the VietGAP program, in which inputs are compulsorily used via standardized schemes. Since farmers need to use pesticides within a specified set of criteria, the health attributes tend to be more evidently perceived from the farmer's viewpoint. As the VietGAP program has been implemented in Thua Thien Hue province for nearly five years, it is easier to compare the health attributes of the VietGAP participants with those of the nonparticipants among local farmers; this provides encouraging proof for the sustainability of the program.

In Germany, previous literature has mentioned the impact of applying standards on agricultural output and farm structure (Pufahl and Weiss, 2008). In particular, the participants of agro-environment program schemes were found to have been able to significantly increase their cultivation area and reduce their purchase of farm chemicals, which accordingly play a vital role in international agricultural trade negotiations. In Kenya, estimation results show that farmers' participation in Global GAP standards has a positive and significant impact on their health, both in terms of a reduction in pesticide-related acute poisonings and their associated cost of illness (Asfaw et al. 2009).

This study expects to contribute to the existing literature on the endogeneity treatment of VietGAP participation via the propensity score matching (PSM) method. The causal effect of certified safe production on household income from economic perspectives has been investigated in other studies using the PSM method (Uematsu and Mishra, 2011). However, in the context of Vietnam, there is still limited data and information about the effect of VietGAP participation on farmers' health when treating the endogeneity of farmers' participation in the program. The decision to participate in VietGAP is self-selection; it can be associated with individual characteristics such as age, educational background, cultivation experience, and production features. Accordingly, the self-selection factor in VietGAP participation can contribute to the endogeneity problem in the empirical analysis of the causal effects of the VietGAP program on the health of local farmers. The PSM method aims to balance the sample into comparable treatment groups—those who are participating in the VietGAP program (i.e., participant group) and those who are not (non-participant group or the control group). By using matching techniques, we can measure the outcome change through the average treatment of the treated (ATT) of VietGAP participation on the possibility that farmers would experience health problems due to pesticide use.

Research objectives

This study generally aims to estimate the impact value of the VietGAP program when applied to vegetable production on the health of farmers. It also aimed to make farmers become more aware of the importance of safe food production as an aspect of health protection. In order to reach these objectives, the following research questions were asked:

(1) Has the VietGAP program improved farmers' health status?

(2) Is there any statistically significant difference in the causal effect of the VietGAP

program on farmers' current health problems due to pesticide exposure?

3 Research method

3.1 Data collection

This study employed secondary and primary data in the analysis. The secondary data consist of the current situation in both conventional vegetable production and safe vegetable production. The data were obtained from provincial documents, annual reports, and project reports. Primary data include a survey of 200 farmers who use VietGAP and conventional vegetable farming methods in Quang Dien, Huong Tra, and Huong Thuy districts in Thua Thien Hue province.

Quang Dien district is known for producing a diverse range of tropical vegetables. The area allotted for vegetable production in the district is 3.880 ha, which accounts for nearly half of its agricultural land. Huong Tra district is the northern gateway to the province, around 17 km from Hue city. The area allotted for vegetable production in Huong Tra is 2.794 ha. Meanwhile, Huong Thuy district is the southern gateway to Thua Thien Hue province, which is around 6 km from Hue city. It has about 1.686 ha of vegetable production area. The farmers of these districts have significant experiences in vegetable production and in the associated supply chain. Vegetable production has traditionally generated a significant income for local farmers in the districts.

Around 150 farming households in Quang Dien district have followed VietGAP production guidelines for five years, and 77 of them working in VietGAP production from 3-5 years are selected to take the survey, and 123 conventional farmers in Quang Dien, Huong Tra, and Huong Thuy districts are based on purposive selection. This research selects farmers who have a long time in VietGAP production because they can recognize the improvement in their health. Although the sample is not equal in each group, PSM method is not affected basing on the balancing test. It satisfies the conditional independence of the PSM method by creating a homogenous sample between VietGAP participants and matched conventional participants. The questionnaire was designed to survey information on individual characteristics, production features, health attributes, and personal perceptions of pesticide hazards and production safety. It is noted that the health attributes include the incidence and severity of health problems derived from exposure to pesticides. Information on pesticide exposure, perceptions of the toxicity of pesticides, and precautionary attitudes were also investigated.

3.2 Propensity Score Matching Method

Factors associated with the probability of VietGAP program participation

The probit model aims to estimate the likelihood of the association of some individual factors with the probability of VietGAP program participation. The equation of the probability of VietGAP program participation was constructed under the following probit models

$$\boldsymbol{Prob}(\mathbf{VietGAP} = \mathbf{1}) = \boldsymbol{\Phi}(\mathbf{X}, \boldsymbol{\alpha}) \quad (\mathbf{1})$$

where *VietGAP* is the binary variable equal to 1 when the respondent has participated in the VietGAP program and 0 otherwise; Φ is the cumulative distribution function of the standard normal distribution; *X* is the set of individual variables, including gender, age, educational background, income, individual habits, production area, cultivation experience, and annual duration of exposure to pesticides; α is the parameter typically estimated by maximum likelihood.

Causal effect of VietGAP program participation on the appearance of health problems due to pesticide exposure

This study employed the PSM method to estimate the average treatment effect (ATE) of VietGAP program participation on farmers' health problems due to pesticide exposure. The decision to participate in VietGAP is self-selection, which is associated with both individual characteristics and production features. In other words, farmers are not randomly assigned to produce vegetables via conventional farming methods or via using the VietGAP procedure. The treated and controls differ with respect to participation status and other characteristics.

The estimation of ATE is ideal when we can simply compare the appearance of health problems due to pesticide exposure when a farmer is using VietGAP products to when s/he is not. In such cases, ATE on the outcome variable can be expressed as

$$\mathbf{ATE} = \mathbf{E}(\mathbf{Y_1} - \mathbf{Y_0}) \quad (\mathbf{2})$$

where Y_1 is the parameter for health problems due to pesticide exposure of farmer with VietGAP participation ($P = 1$); Y_0 is the parameter for health problems due to pesticide exposure of farmers without VietGAP participation ($P = 0$).

However, one practical problem that arises given a cross sectional data set is that we can only observe either Y_1 or Y_0 because the assignment is mutually exclusive. Thus, estimating the ATE of being a VietGAP farmer on the appearance of health problems due to pesticide exposure hinges on the estimation of the counterfactual (Wooldridge, 2001). Thus, it is necessary to estimate the appearance of health problems due to pesticide exposure that a farmer participating in the VietGAP program would have gotten if s/he were not participating in the program, or that of a conventional farmer had s/he been participating in the program.

When the assignment to the treatment group can be fully explained by observable variables, any bias inherent in comparing the outcome variables between the control group (conventional farmers) and the treatment group (VietGAP farmers) can be removed by matching the observations in the two groups based on observable variables. When observations in the VietGAP group can be matched against observations in the conventional group that shares similar characteristics based on observable variables, any difference in the outcome variables that may exist can be assumed to be independent of the treatment status.

Rosenbaum and Rubin (1983) proposed the propensity score, which is a conditional probability of VietGAP participation, as follows:

$$\mathbf{P}(\mathbf{X}) = \mathbf{Prob}(\mathbf{P} = \mathbf{1} \mid \mathbf{X}) \quad (\mathbf{3})$$

Matching is a non-experimental method of evaluation that is used to estimate the average effect of the VietGAP program. This method compares the mean of the possibility of health

problems due to pesticide exposure in VietGAP farmers with those of matched conventional farmers; matches are chosen based on the similarity in observed characteristics. In this study, the average treatment effect for the treated (ATT) can be formulated as

$$\mathbf{ATT} = \mathbf{E}(\mathbf{Y_1} - \mathbf{Y_0} \quad \mathbf{P} = \mathbf{1}) = \mathbf{E}(\mathbf{Y_1} \quad \mathbf{P} = \mathbf{1}) - \mathbf{E}[\mathbf{Y_0} \quad \mathbf{P} = \mathbf{1}] \qquad (\mathbf{4})$$

It is important to note two assumptions:

(1) Conditional independence

This implies that given a set of observable X, potential outcomes are independent of treatment assignment after the balancing test (Y_1, Y_0) $\perp$ P (X). This procedure assumes that after conditioning on a set of observable characteristics, outcomes are conditionally mean independent of program participation. Any remaining difference in the outcome variable can be solely attributed to treatment status. Assignment to the treatment can be considered purely random among observations with similar observable characteristics.

(2) The overlap

If $0 < P(X) < 1$, then the probability of participation ranging from 0 and 1 can be considered as common support.

When these assumptions are satisfied, assignment to treatment is random for observations with the same propensity score. Observations in the control and treatment groups can be matched according to the propensity score.

In short, PSM balances the sample into comparable participant (treatment) and non-participant (control) groups; the method uses matching techniques to measure the outcome change through ATT. Because it is not feasible to find an exact match for every treated observation, a number of matching procedures have been proposed in the literature, including nearest-neighbor matching, radius matching, kernel matching, and local linear regression matching (Becker and Ichino, 2002). It is important to note that propensity score matching does not eliminate the selection bias due to unobservable factors that explain the assignment to treatment, but it only reduces it (Becker and Ichino, 2002). The significant results of matching methods will provide evidence of the improvement of VietGAP farmers' health.

4 Results and discussion

4.1 Individual factors associated with the probability of participation in the VietGAP program

The probability that a farmer would participate in the VietGAP program can be predicted based on certain factors, e.g., demographic characteristics, educational background, economic conditions, and production features. Table 1 proposes some related variables (and their definitions) that could affect the probability of VietGAP participation among farmers.

Table 1. Definitions of variables

Variables		Definition
Demographic characteristics	Gender	= 1 if respondent is female and 0 for male
	Age	= 1 if respondent is aged 25–35 years old; = 2 for aged 35–45 years old; = 3 for aged 45–55 years old; = 4 for aged > 55 years old
Educational background	Education	= 1 if respondent has no schooling; = 2 for primary school; = 3 for secondary school; = 4 for high school; = 5 for university/college or higher
Economic circumstances	Income	Monthly average income (million VND)
Production features	Area	Production area
	Cultivation experience	= 1 if cultivation experience is < 5 years; = 2 for 5–10 years; = 3 for 10–15 years; = 4 for > 15 years
	Training courses	Number of training courses on production safety farmers have attended in their local area
VietGAP participation	VietGAP	= 1 if respondent has been participating in VietGAP program, 0 otherwise
Health problem appearance	Health problems	= 1 if respondent has health problems from exposure to pesticides, 0 otherwise

Source: survey in 2015

The variables are statistically illustrated in Table 2. The relevant factors are shown in the classification of the VietGAP group of 77 farmers (the treatment group) and the conventional group of 123 farmers (the control group). In general, differences in the variables by participation program status could be found in age, education, cultivation experience, the number of training courses undertaken on production safety and health problem appearance. As seen from the mean value, VietGAP farmers tend to be younger, a higher proportion of them is male, they tend to have achieved a higher educational level, have more cultivation experience, and have attended a greater number of training courses on production safety than conventional farmers do. Smaller production areas, mainly under parcel management, are more popular among VietGAP farmers than conventional farmers. The detailed statistical significance of difference could be obtained by the t-test used in the next section. Economic circumstances were not significantly different between the two groups.

Table 2. Statistical description

Variables	VietGAP Farmer				Conventional Farmer			
	Mean	Standard Deviation	Min	Max	Mean	Standard Deviation	Min	Max
Gender	0.12	0.32	0	1	0.28	0.45	0.0	1
Age	2.87	0.91	1	4	3.19	0.75	2.0	4
Education	2.88	0.74	2	4	2.11	0.87	1.0	5
Income	2.86	0.85	1	5	2.96	1.13	0.5	6
Area	1.70	0.56	1	3	1.99	0.88	1.0	5
Cultivation experience	2.78	0.77	2	4	2.38	0.95	1.0	4
Training courses attended	3.01	1.25	0	4	2.44	1.25	0.0	4
Health problems	0.05	0.22	0	1	0.44	0.50	0.0	1
No. of observations	**77**				**123**			

Source: survey in 2015

Table 3 shows that younger farmers with a higher level of education and with more experience of cultivation have a 30 % higher probability of joining the VietGAP program than older farmers. Younger farmers also have higher willingness to change their production practices to incorporate more up-to-date agricultural science. We also found that an increase in the educational level of farmers resulted in a 60 % increase in involvement in the program. Farmers who have a higher level of education tend to be more flexible in their approach to participating in technical training, found it easier to adapt to new production methods, and paid more attention to protection procedures that benefit health, as compared to farmers with less education. Cultivation experience, in particular, is a critical determinant for farmers wishing to participate in the safe production of vegetables. Results show that the group of farmers with more experience has a 48 % higher probability of engaging in the VietGAP program than farmers with less experience. Farmers with a senior level of cultivation experience and more accumulated cultivation skills are preferable for involvement in the VietGAP program than farmers of a junior level. The farmer who attends more training courses has a 26 % higher probability of participating in the VietGAP program.

In summary, the VietGAP program is more relevant to farmers with a higher educational background, more experience of cultivation, and higher attendance at training courses on production safety. Gender, the area of land under cultivation, and income are not significant when determining VietGAP program participation.

In addition to age, educational background, cultivation experience, and the number of training courses attended, we also considered the size of a farmer's production area and whether this could impact directly or indirectly on pesticide exposure-related health problems. "Production area" refers to the level of resource investments such as time and/or labor spent on agricultural production; this can increase exposure to pesticides, which can lead to health problems.

Table 3. Factors associated with the probability of VietGAP participation

Factors/Determinants	Probability of VietGAP Participation	
	Coefficient	Standard Error
Gender	–0.21	0.28
Age	–0.30**	0.15
Education	0.60***	0.13
Income	0.07	0.19
Area	–0.45	0.26
Cultivation experience	0.48***	0.14
Training course	0.26***	0.09
Pseudo R^2	0.26	
Number of observations	200	

Note: *, **, and *** denote statistical significance at the 10 %, 5 %, and 1 % levels, respectively.

Source: survey in 2015

4.2 Average effect of VietGAP program participation on health

This research aims to explore if there is any significant difference between the health status of VietGAP farmers and that of conventional farmers. Observable factors, to some extent, can affect the selection of VietGAP program participation. As clarified previously, some factors are found to be different between the two groups. A t-test shows that the mean values of the variables: gender, age, educational level, area of land under cultivation by one farmer, cultivation experience, and number of training courses on production safety are found to have a statistical difference between the treatment group (i.e., VietGAP farmers) and the control group (i.e., conventional farmers) at the 5 % level. The results of the t-test reaffirm the selection features of the VietGAP program since participation is more attractive to younger people with a higher educational background, more experience of cultivation, and a lower rate of exposure to pesticides.

Since some factors have statistically significant differences between VietGAP farmers and conventional farmers, the balancing test from Table 4 aims to satisfy the conditional independence of the PSM method by creating a homogenous sample between VietGAP participants and matched conventional participants. This study employed the techniques of nearest neighbor matching, caliper and radius matching, kernel matching, and local linear regression matching. The balancing test guarantees that the mean values of explanatory variables between the two groups have no statistically significant difference. Therefore, the self-selection feature of the VietGAP program participation (considered an endogeneity problem) could be ultimately eliminated from this process. Accordingly, the measurement of the causal effect of the VietGAP program on health problems due to pesticide exposure among farmers could be obtained more precisely.

After the balancing test, the above techniques of the PSM method were implemented to obtain ATT. ATT measures the causal effect of VietGAP program participation on the health problems experienced by farmers due to pesticide exposure.

The results from the four matching techniques, shown in Table 5, simultaneously show the significant impact of VietGAP program participation on health with statistical significance at the 1 % level in nearest-neighbor matching, caliper and radius matching, kernel matching, and local linear regression matching. In terms of ATT, the evidence derived from the four types of matching proves that participating in the VietGAP program lowers the probability of health problems due to pesticide exposure by 15.6 % (nearest-neighbor matching), 22.9 % (caliper and radius matching), 25.5 % (kernel matching), and 23.6 % (local linear regression matching). The positive effect of the VietGAP program on the health of farmers is significant for policy makers, who should provide and broaden incentives for farmers to move production behavior toward environment-friendly procedures in order to increase health protection and improve food safety.

Table 4. Balancing test

Variables	Parameters	Before Matching	After Nearest Neighbor Matching	After Caliper and Radius Matching	After Kernel Matching	After Local Linear Regression Matching
Gender	Mean (treated) Mean (controls) t-test (P-value)	0.120 0.280 0.007***	0.12 0.13 0.81	0.12 0.13 0.87	0.12 0.10 0.81	0.12 0.13 0.81
Age	Mean (treated) Mean (controls) t-test (P-value)	2.870 3.190 0.008***	2.87 2.87 1.00	2.87 2.89 0.91	2.87 2.88 0.93	2.87 2.87 1.00
Education	Mean (treated) Mean (controls) t-test (P-value)	2.880 2.110 0.000***	2.88 2.78 0.43	2.88 2.86 0.84	2.88 2.83 0.70	2.88 2.78 0.43
Income	Mean (treated) Mean (controls) t-test (P-value)	2.860 2.960 0.500	2.86 2.81 0.74	2.86 2.88 0.90	2.86 2.84 0.90	2.86 2.81 0.74
Area	Mean (treated) Mean (controls) t-test (P-value)	1.700 1.990 0.011**	1.70 1.66 0.68	1.70 1.73 0.72	1.70 1.71 0.97	1.70 1.66 0.68
Cultivation experience	Mean (treated) Mean (controls) t-test (P-value)	2.780 2.380 0.002***	2.78 2.99 0.11	2.78 2.89 0.42	2.78 2.94 0.23	2.78 2.99 0.11
Training courses undertaken	Mean (treated) Mean (controls) t-test (P-value)	3.010 2.440 0.002***	3.01 2.81 0.30	3.01 2.77 0.22	3.01 2.78 0.25	3.01 2.81 0.30

*Note: *, **, and *** denote statistical significance at the 10 %, 5 %, and 1 % levels, respectively.*

Source: survey in 2015

Table 5. Average effect of farmers' participation in VietGAP program on the appearance of health symptoms on farmers due to pesticide exposure

Matching type	Parameters	ATT	No. of observations
Nearest-Neighbor	Mean (treated)	0.052	200
	Mean (controls)	0.208	
	Diff	– 0.156***	
Caliper and Radius	Mean (treated)	0.052	
	Mean (controls)	0.281	
	Diff	– 0.229***	
Kernel	Mean (treated)	0.052	
	Mean (controls)	0.307	
	Diff	– 0.255***	
Local Linear Regression	Mean (treated)	0.052	
	Mean (controls)	0.288	
	Diff	– 0.236***	

*Note: *, **, and *** denote statistical significance at the 10 %, 5 %, and 1 % levels, respectively.*

Source: survey in 2015

5 Conclusions and policy implications

5.1 Conclusion

The VietGAP program provides standard types and uses of fertilizers and pesticides. Most VietGAP pesticides originate from biological products, and the pesticide use is strictly regulated. The VietGAP production procedure follows a particular set of technical criteria in terms of input management for seeds, fertilizers, plant protection products, harvest management, and waste management. Health attributes during production are described through the appearance and the economic value of the health problems resulting from exposure to pesticides.

Results of this study show that after nearly five years of VietGAP's implementation, the program has significantly improved the health status of local VietGAP farmers. Since VietGAP participation can be assigned from observable factors, we used the PSM method to obtain the average causal effect of VietGAP program participation on health problems due to pesticide exposure among farmers. The findings imply that VietGAP program participation is significantly associated with the farmer's age, educational background, cultivation experience, and incidence of pesticide exposure. After applying a balancing test to treat the self-selection feature and endogeneity problem of VietGAP program participation, we found that participating in VietGAP program significantly lowers the probability of pesticide exposure-related health problems by 15.6 %, 22.9 %, 25.5 % and 23.6 % using the methods of nearest-neighbor matching, caliper and radius matching, kernel matching, and local linear regression matching, respectively. The VietGAP program has moved farmers toward environment-friendly production methods that provide greater health protection and environmental sustainability. The positive health impacts of the VietGAP program are expected to encourage farmers to change their production behaviors. Overall, the VietGAP vegetable production is a good program for promoting environment-friendly production for farmers.

5.2 Policy implication

Production-related solutions

The production area under the VietGAP program should be extensively and intensively broadened in tandem with rural development programs aimed at enhancing the value of traditional activities. Production processes should improve the quality of inputs, especially seeds and fertilizers, to increase crop productivity and the value added. The use of permitted biological products should also be promoted in production and pest management. Likewise, education among farmers with regard to pesticide safety should be expanded. The government should also promote the use of quality-guaranteed protection equipment when using pesticides in crop production. In connection with this, farmers should avoid using excessive amounts of chemical pesticides that harm their health.

The types of vegetables grown should also be diversified. Farmers should also consider investing in those vegetable varieties that can adapt to local conditions, have a high commodity value, and have high economic efficiency. Moreover, farmers need to ensure the quality of their

products; once farmers guarantee the quality and quantity of the commodities, the promotion of safely produced vegetables can take place.

Consumption-related solutions

In Thua Thien Hue, VietGAP products face difficulties regarding market access. A large volume of vegetables are produced via conventional farming methods, and these dominate the market. Vegetables produced via VietGAP are not as popular because they are relatively more expensive—they cost 10-20 % more than conventionally produced food products.

VietGAP produce faces competition from products inside and outside Thua Thien Hue province. The traditional consumption habits of consumers ensure that local people buy food on a daily basis at the most convenient location, at the most convenient time, at the best price, and with a scant regard to whether the products are guaranteed by a particular certification or source. The weakness lies in the inability to promote safe vegetables at designated places (such as supermarkets), thus limiting their purchase.

VietGAP farmers also need to sell their produce in the same way that conventional farmers do because they cannot preserve vegetables for long after harvesting. Therefore, a systematic and effective supply chain for safe vegetables needs to be developed; this needs considerable technical and financial investment in the production process and distribution channels.

Consumption solutions should be oriented toward setting up guaranteed outlets at local markets and within supermarkets where safe vegetables can be sold. Some customers agree that safe vegetables should cost more, even 20-25 % more, but they also want their quality to be guaranteed and to be accessible for purchase. Likewise, local officials should enhance community perceptions of safe vegetables and encourage their consumption as part of health improvement.

Consumers' confidence on safe vegetables plays an important role in the promotion of VietGAP products. Once consumers gain confidence in locally produced safe food products, it is expected that they will engage in better consumer behaviors. Women are usually the decisive actors in choosing and preparing a family's food—their consumer behavior affects the quality of food a family eats every day and, therefore, the family's long-term health. Accordingly, housewives' knowledge on environment-friendly food products should be improved in order to bring positive impacts on family health. Marketers should also provide incentives to improve the advertising of safe food via the mass media, with the aim of broadening the safe food trademark and increasing confidence in locally produced safe food products.

Management-related solutions

Quality assurance should be promoted in terms of packaging, trademark, and price point in order to increase the value of safe food products. In transporting vegetable commodities, quality assurance should be guaranteed to safeguard the freshness of safe food products. Local officials and academics should improve the provision of technical assistance to improve quality assurance. Training courses should aim to transfer the skills needed to change cultivation methods and should provide guidance in using fertilizers and plant protection instruments, monitoring the harvest, and monitoring the final product. Local governors and agricultural

cooperatives should engage in quality assurance of inputs, the production process, and the supply chain under the assigned criteria in order to move forward to health protection for communities.

Given the time constraints, this research only concentrates on the commonly self-reported health problems resulting from using pesticides via conventional production and via VietGAP production, providing the empirical evidence of the probability of pesticide exposure-related health problems. Based on this finding, the evaluation of economic value on farmers' health will be conducted in the future to identify the health impact value of VietGAP participation. It will contribute to expanding the VietGAP program in Thua Thien Hue province.

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