Food-safety Standards and Farmers Health: Evidence from Kenyan's Export Vegetable Growers

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1. Introduction

In recent years, governments and development agencies have sought to promote the diversification of African agro-food exports in order to accelerate economic growth, expand employment opportunities, and reduce rural poverty (Harris *et al.*, 2001). Particular attention has been given to facilitating the export of high-value horticultural products, which have grown steadily to become the single largest category in world agricultural trade, accounting for over 20% of such trade in recent years (Humphrey, 2006). A number of African countries have had some notable success in such export diversification among them Kenya is leading. Horticultural products have accounted for two-thirds of all growth in agricultural exports and recently surpassed coffee to become the first largest merchandise export together with tea (GOK, 2006). Small-scale farmers have proven to be effective suppliers of horticultural products when satisfactory contracting arrangements are established with an exporter or processing firm (Dolan and Humphrey, 2000).

However, there are problems in horizon for export horticulture in Kenya – and may be equally applicable elsewhere in Africa and these problems will have a profound impact on small-scale farmers. Increased intensity in export market production has led to the use of relatively large quantities of pesticides often not for the purpose of preventing yield loss but in order to satisfy export markets' demand for aesthetic appeal. Intensive use of chemicals has been associated with a high risk to human health (chronic and acute illness) and intolerable environmental pollution (Crissman *et al.*, 1998; Mwanthi and Kimani, 1990; Rola and Pingali, 1993; Thrupp, *et al.*, 1995; Ohayo-Mitoko, 1997; Maumbe and Swinton, 2003; Okello and Swinton, 2006; Garming and Waibel, 2008). As a result consumers and authorities in the importing developed countries are becoming increasingly concerned about the prevailing production methods in the exporting countries. Various rules and regulations have been put in place to protect consumers and farm workers from pesticide intoxication and restore consumer confidence. The European Union, Kenya's major export market, has enacted legislation on maximum residue limits (MRLs), sanitary and phytosanitary (SPS) and traceability requirements. In parallel with changes in official standards, supermarket chains in Europe have also developed prescriptive, production-oriented standards, the EU Retailers Produce Working Group for Good Agricultural Practices (GlobalGAP)[1] that are meant for growers of fresh fruit and vegetables and require certification by an independent internationally accredited certification body[2].

[1] This study was conducted when EurepGAP, Version 2.1 (October 2004) was relevant. Since then EurepGAP has changed its name and logo to GlobalGAP, arguing that its proclaimed role in promoting the harmonization of good agricultural

The GlobalGAP schemes are based on compliance with four main criteria: food-safety, environmental protection, occupational health and safety, and animal welfare. The food-safety criteria are based on the application of Hazard Analysis Critical Control Point (HACCP) principles, while criteria for the environment are designed to minimize the negative effects of agricultural production. While a minimal level of occupational health and safety is part of GlobalGAP, this is not regulated through in-depth audits of social conditions. Compliance with GlobalGAP is assessed by use of control points, which are classified into three levels of importance: 'major musts', 'minor musts' and 'recommendations'. Major musts are standards that have to be met with 100% compliance (GlobalGAP 2004). All control points that relate food-safety, and some points associated with occupational safety, belong to this category. At present, over 250 control points have been identified in GlobalGAP for fresh fruit and vegetables, of which over 50% define criteria for the correct use of chemicals for pre-and post-harvest treatment (GlobalGAP, 2004). To comply with these standards, producers generally have to change their production technology, e.g. switch to less harmful pesticides and invest in structures such as grading sheds, charcoal coolers, disposal pits, toilet and washing facilities, pesticide stores etc.

In spite of the growing recognition of the hidden costs related to the environmental and health effects due to pesticide use and the potential of adoption of production standards such as GlobalGAP to reduce them, there is lack of empirical evidence to support the prepositions. Theoretically adopting food-safety standards like GlobalGAP provides potential health and environmental benefits stemming from changes in pesticide use and hygienic practices. Standards, if adopted could reduce exposure of developing country farmers to highly toxic pesticides and hence cost of pesticide-related illnesses. Measures taken to meet export market requirements for food-safety usually have spill-over benefits for other (non-export oriented) local producers or for domestic consumers. Referring to these potential direct and indirect benefits, some argue that standards can play a positive role, providing the catalyst and incentives for the modernization of export supply and regulatory systems and the adoption of safer and more sustainable production practices in developing countries (Henson and Jaffee, 2006; Maertens and Swinnen, 2006). On the other hand there is an argumentation that the proliferation and enhanced

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practices schemes had moved beyond Europe. The name change was announced at the 8th EurepGAP Conference, the EurepGAP Asia Conference, held in Bangkok on 6th and 7th September 2007. Therefore, throughout this paper the term GlobalGAP is used, and can be considered as synonymous to EurepGAP.

[2] Beside GlobalGAP there are other standards such as British Retail Consortium (BRC), Hazard Analysis Critical Control Point (HACCP), TNC (Tesco's Nature Choice) and ISO 9001:2000 that are relevant for the sector in Kenya. Nevertheless, these standards are more stringent than GlobalGAP and are primarily adopted by large-scale producers. There was no smallholder group certified under these other standards during our survey period and hence our study mainly focuses on smallholders producing under GlobalGAP.

stringency of food-safety standards that are imposed by high-income countries result in the marginalization of resource-poor farmers from the lucrative export market and convey adverse poverty impact (Reardon *et al.*, 2003; Weatherpoon and Reardon, 2003; Jensen, 2004; Humphrey, 2006).

Limited empirical evidence exists either to confirm or refute the hypotheses that food-safety standards confer a positive external effect on farmers adopting it. Incorporating these health effects in the analysis could help to improve understanding of the true impact of emerging production standards on developing countries farmers. Therefore this paper assesses the effect of standards on (i) pesticide related incidence of acute poisoning symptoms and (ii) its associated cost of illness. Given a time and resource constraint, this paper focuses on self-reported health symptoms associated with pesticide use and its corresponding cost ignoring other potential health effects such as genetic and reproductive disorders as well as cancers.

In addressing these objectives, the contribution of this paper to the literature is threefold. First, there is limited empirical evidence to test the hypothesis that food-safety standards confer a positive external effect on farmers adopting it. While some prior studies have analysed the income effect of standards, this study investigates the link between adoption of food-safety standards, pesticide use and farmer health. Second, in much of the previous literature (e.g. Okello, 2005) on private standards, self-selectivity (or endogeneity of adoption of standards) was not explicitly being dealt with. The decision to participate in export market and, therefore, adopt the relevant food-safety standards is not a random event and depends on a number of observable and unobservable factors. This paper addresses the issue using instrumental variable econometric techniques. Third, the paper draws upon a relatively large sample data set, which was collected via re-call and season-long monitoring survey.

The remainder of the paper is structured as follows. Section two presents the data collection methodology. The econometric model used for estimation is presented in section three. Section four presents the estimation results and some conclusions and policy implications of the study are pointed out in section five.

2. Survey design and data

A multi-stage sampling procedure was used to select districts, sub-locations[3] and small-scale vegetable producers. In the first stage, five districts were selected from the two major vegetable producing provinces (namely Nyeri, Kirinyaga, and Murang'a districts in Central Province and Meru Central and Makueni districts in Eastern Province) based on the intensity of export vegetable

[3] Sub-location is the lowest administrative unit in Kenya and is composed of small villages.

production, agro-ecology, types of crop produced and accessibility. Meru district is located at a higher altitude (above 2300m) primarily producing French beans, while Nyeri, Kirinyaga, and Murang'a districts are situated at a middle altitude (1850 – 2100m) producing a range of green beans and peas. Makueni district is located at a lower altitude (600 – 1100m) mainly producing Asian vegetables such as okra, chillies, and aubergines. These districts represent the major export vegetable producing areas, which cover approximately half of all smallholder export vegetable producers in Kenya (Mithöfer *et al.*, 2008). Since the number of export vegetable producers among the districts varies, and to ensure that every element in the target population has an equal chance of being included in the sample, we used the Probability Proportional to Size (PPS) sampling technique. Overall, 21 sub-locations were randomly selected from the five districts by PPS sampling procedures and a total of 439 vegetable producer households were selected randomly for the interviews. Of these 149 are GlobalGAP adopter export farmers and 290 are non-adopter export farmers. GlobalGAP adopters in this case are defined as small-scale export producers who have either already obtained GlobalGAP certification or are in the process of obtaining the certificate under Option 2[4]. Non-adopters are export farmers who are not involved in any way in the process of GlobalGAP certification.

Data collection took place during the 2005/2006 cropping season. For each randomly selected farmer, the survey consisted of a single visit (re-call survey) and a season-long monitoring of household production practices. The data were collected by trained enumerators supervised by the first author, using structured questionnaires. Prior to commencing the survey the questionnaire was pre-tested on non-sampled farmers separately for validation. The re-call survey questionnaire covered specific information on the characteristics of household members, household income (both farm and off-farm), household assets such as land and livestock ownership, farm machinery and household equipment, as well as access to different services such as credit, irrigation, formal contracts and group membership. The farmers were also asked to re-call incidences of intoxication after applying pesticides on export vegetables during the past three years. Nevertheless while conducting the survey it was realized that using health information collected via recall survey could lead to misleading conclusion since most farmers could hardly remember the pesticide ascribed health problems in prior years. Hence we decided to collect health information together with production inputs and outputs related to export vegetable production via season-long monitoring survey.

[4] GlobalGAP offers four types of certification, although in Kenya at the time of the survey only two of them were applied. Under Option 1 individual farmers apply for certification and under Option 2 a group of farmers applies for a group certificate. Farmers must invest in the infrastructure necessary for GlobalGAP, establish an internal management and control system, perform individual self-inspections and group internal inspections before receiving an external verification by a certification body (GlobalGAP, 2004).

The monitoring questionnaire was administered exclusively to the farmer after every three weeks throughout the cropping season. A health symptom that the farmers reported is regarded to be associated with pesticide spraying if the symptom only began during the spraying operation or within 24 hours after spraying. If the household members experienced any sort of pesticide intoxication, then he/she was asked to report for each symptom, the number of times the symptom occurred, number of work-days lost partially or completely due to the health symptoms and the type of medication taken by victims. Other data collected include direct costs of the symptoms, i.e. pharmacy cost and consulting fees and indirect costs such as travel expenses to and from health centers. Beside health information, a host of data were collected on type of pesticides sprayed, the quantity sprayed, and many others pesticide management practices indicators such as whether protective clothing was used by sprayer, precautionary measures was taken against wind, condition of spraying equipment used etc.

An estimate of pesticide related health cost is computed as the sum of farmer-reported medical treatment costs to clinics and private physicians, the opportunity cost of work days lost to illness[5], travel costs to and from health facility, time spent in traveling and the cost of home-based health care. This estimate is expected to be the lower bound of the true cost of illness since other costs such as loss of labor by family members nursing the victim, work efficiency loss in farm due to illness, the value of leisure forgone due to illness, cost of defensive expenditure and the cost of traditional healing strategies are not included in our computation due to lack of information.

3. Empirical models

Following Rosenbaum (1983), Green (1997), Angrist (2001), Wooldrige (2002) and Fernandez-Cornejo *et al.* (2005), different econometric techniques are applied to correct for potential selection bias in estimating the impact of standards on farmers' health.

Treatment effect model and propensity score methods

The major question is what would the cost of illness of GlobalGAP adopters have been if they had not adopted standards? To answer this question a suitable comparison group of non-adopters whose outcomes, on average, provide an unbiased estimate of the outcomes that the adopters would have had in the absence of standards needs to be identified. The choice of counterfactual is crucial because adopters are not placed randomly and the decision to adopt depends on individual, household,

[5] The opportunity cost of work days lost and time spent in travelling is converted into monetary values by making use of the existing wage rate in the nearest village.

community characteristics and other exogenous factors. Formally, given the unobserved variable and its observed counterpart, the treatment-effect equation can be expressed as:

$$G_i^* = \beta Y_i + u_i \tag{1}$$

$$H_i = \alpha J_i + \gamma G_i + e_i \tag{2}$$

$$G_i = \begin{cases} 1 & if\ G_i^* > 1 \\ 0 & otherwise \end{cases} \tag{3}$$

where G_i^* is the unobservable or latent variable for GlobalGAP adoption, G_i is its observable counterpart (dummy for adoption of GlobalGAP), H_i is a vector denoting the cost of illness, J_i are vectors of exogenous variables thought to affect health cost and Y_i are non-stochastic vectors of observed farm and non-farm characteristics determining adoption (number of adult females, age of household head, educational attainment, access to facilities, level of agricultural training, total hours spent listening to radio per week, total hours spent watching television per week, use of mobile phone, contact to extension service, access to formal contract, duration of group membership, years of export production, use of irrigation and participation in off-farm activities). e_i and u_i are random disturbances associated with the cost of illness model and the adoption of GlobalGAP. In Equation (1), the dependent variable adoption of GlobalGAP standards equals one, if the farmer has commenced to comply with GlobalGAP code of practices during survey period, and zero otherwise. It is generally assumed that the household's aim to maximize its expected utility subject to various constraints determines the decision to adopt emerging standards. Based on this assumption, a number of observable factors are hypothesized to affect the adoption decision[6]. Note that we cannot simply estimate Equation (2) because the decision to adopt may be determined by unobservable variables that may also affect health cost. If this is the case, the error terms in Equation (1) and (2) will be correlated, leading to biased estimates of γ, the impact of adopting GlobalGAP. Potential selection bias can be corrected by assuming a joint normal error distribution, and using a two-step procedure. In fact we have performed a Wu-Hausman specification test (Hausman, 1978) to test the null hypotheses that GlobalGAP adoption is exogenous in the cost of illness function. The P-values of the estimated F-test statistics show that the exogeneity hypothesis is rejected at the 5% level of significance. The test suggest that farmers' decisions to adopt GlobalGAP standards are endogenous in the health function

[6]Results of the first stage adoption equation are not discussed in this paper since it was presented in previous publications however it could be available on request.

model and need to be accounted for to obtain efficient and consistent estimates. However whether or not the effect of a treatment (GlobalGAP adoption) can be correctly estimated using a two-stage regression importantly depends on the validity of the exclusion restriction. Hence for identification purpose, we followed the usual order condition that Y_i contains at least one element not in J_i imposing an exclusion restriction in Equation (2).

For the first stage, our identification strategy is based on variations in the stock of social capital enjoyed by different households. Our hypothesis is that the probability of a household adopting GlobalGAP is an increasing function of its "stock of social capital" within the rural community, reflected by three instrumental variables: the number of years a household has been producing for the export market; duration of group membership; the number of years the household has been using a mobile phone. These variables do not have any direct effect on cost of illness, though are hypothesised to affect the probability that the household adopts GlobalGAP standards. The validity of our results depends to a large extent on the quality of these instruments. We assess the quality of our instrument by using an F-test of the joint significance of the excluded instruments. According to Stock and Staiger (1997), the weak instrument hypothesis will be rejected if an F-test is greater than 10. Additionally as part of robustness check, we also perform overidentification tests of the model.

To assess the heftiness of the first model results, we also use an alternative propensity scores as control functions in case the adoption variable interact with unobserved heterogeneity (Wooldridge, 2004) – a method pioneered by Rosenbaum (1983):

$$H_i = \alpha J_i + \gamma G_i + \mu Pscore + e_i \qquad (4)$$

where

$$Pscore(Y) = \Pr(G_i = 1 / Y) \qquad (5)$$

The propensity score (*Pscore*) is the conditional probability of adoption given observed covariates Y and can be estimated by a probit model. The estimated propensity scores are used in the structural equation as a control function for selection bias. A key assumption underlying this method is ignorability of treatment, which implies that the potential outcomes are independent of participation conditional on the set covariates (Rosenbaum, 1983; Wooldridge, 2004).

$$(H_1, H_2) \perp G_i / Y \qquad (6)$$

where H_1 and H_2 are the outcomes of interest (cost of illness) for adopters and non-adopters, respectively.

Two-stage Poisson regression model

The second regression model involves the estimation of determinants of acute symptom incidence of pesticide poisoning. Acute symptom incidences refer to short-term illness episodes experienced by the farmers and these include both the dermal and oral (ingestion) symptoms. Thus, the total incidence model aggregates skin irritation, diarrhea, sneezing, headache, dizziness, vomiting, stomach poisoning, blurred vision, eye irritation and backache episodes incurred by the household members during and/or soon after spraying pesticides.

The response variable in this situation is a quantitative variable, but has the property that it is discrete, taking on only integer values. This dependent variable is addressed via Poisson regression model. The basic idea for this model is that the predictor information is related to the rate or susceptibility of the response to increase or decrease in counts. Econometric model of count data give consistent estimate only when the regressors are exogenous. In the present study, however, the main regressor of interest is adoption of standards, which is endogenous as shown in the Hausman specification test. Hence a two-stage estimation procedure is applied.

The estimation of linear models with endogeneity is to some extent straightforward, but a situation in which a count dependent variable depends on a binary endogenous variable is more complex because a simple reduced form does not exist. There are two standard approaches to estimation. The first approach is a full information maximum likelihood, FIML, model in which the joint distribution is specified and the joint log-likelihood function is maximized. Alternatively, a limited information maximum likelihood, LIML, two-step procedure can also be adopted. In this approach, we estimate the first model, since it does not involve the second parameter vector. Subsequently, the second parameter vector is estimated conditional on the results of the first step estimation. Consider the following two equations:

$$\begin{aligned} H_i &= \exp(\alpha_i J_i + \gamma_1 G_i + u_i) = \exp(\alpha_i J_i + \gamma_1 G_i)\exp(u_i) \\ &= \exp(\alpha_i J_i + \gamma_1 G_i)\varepsilon_i \end{aligned} \qquad (7)$$

$$G_i^* = \beta Y_i + u_i \qquad (8)$$

where H_i is a count endogenous variable, G_i is a binary endogenous variable, J_i and Y_i are exogenous variables, ε_i and u_i are disturbance terms that follow a gamma distribution and a logistic distribution, respectively and G_i^* is an unobservable variable. From the viewpoint of model estimation, however, the model described above cannot be estimated using fully simultaneous estimation due to logical consistency (Windmeijer and Santos Silva, 1997; Mullahy, 1997; Cameron and Trivedi, 1998; Winkelmann, 2003). As a result, the parameters are estimated by maximizing the log-likelihood function using limited information maximum likelihood estimation[7]. The stata commands are used as provided by Hardin (2002) for estimation and the standard errors are also adjusted to account for the two-step procedure. Descriptions of the variables used in the analyses and basic statistics are provided in Table 1.

Table 1 Here

4. Results and discussion

Results of pesticide-ascribed acute illness model

As shown in Table 2 the results demonstrate that the two-stage Poisson regression model performed well in explaining self-reported acute symptoms of pesticide poisoning, with reasonable explanatory power for cross-section data (Pseudo R-squares of 0.34). Over-identification tests for the first stage adoption model did not support the validity of duration of group membership which was therefore dropped as an instrument. The test does not reject the validity of years of production for export market and use of mobile phones, and hence they were used as instruments. The F-statistic of joint significance of the excluded instruments is greater than 10, thus passing the test for weak instruments. The null hypothesis in the over-identification test is that the instruments are valid.

Table 2 here

Pesticide use significantly affects farmer's health impairments. The statistically significant and positive coefficient for categories I and II pesticides indicates the incidence of farmer's health impairments rises with the increase in highly toxic pesticide use. Although the coefficients are insignificant, categories III pesticide types are positively correlated with incidence of acute poisoning. It is hypothesized that using pesticide cocktails can increase incidence of symptoms in the household due to the possible interaction between pesticides that can lead to unknown chemical reactions (Yánez *et al.*, 2002). The results do not support this notion since the coefficient is not statistically significant. It is interesting to note the significant negative coefficient for age, which indicates the older the farmer, the more experience in pesticide use resulting in better health. However as displayed with the positive and significant coefficient of age square, the ability of farmers to appropriately use pesticides decreases

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[7]We imposed an exclusion restriction in equation (14) i.e. Y_i contains at least one element not in J_i. Our identification strategy for the first stage is based on variations in the stock of social capital enjoyed by different households, which is similar to the identification strategy presented for the previous model.

after a certain threshold of age resulting in health problems. The result that age squared is positive and significant might also be related to the increasing evidence of chronic health effects when farmers get older; a generally declining health status or accumulation of pesticide contamination after many years of working with pesticides (Hernández-Volero *et al.*, 2001). The regression results also depicts that incidence of health impairment is higher among male farmers than females, which is consistent with the researchers' observation during the field survey. Pesticide applicators in the study area are primarily male farmers whereas the female farmers engage in other farming activities such as weeding and harvesting.

Previous studies have shown that the higher the level of training or education within the household, the more likely to report pesticide-related health symptoms simply because of the awareness of negative effects on health. However our findings show that expected number of training sessions tends to decrease the number of reported pesticide-related acute illness. Likewise the incidence of acute illness symptoms is also mitigated by knowledge of pesticide labels as indicated by negative and significant coefficient of the variable. Other human capital variables such as education level of the head and contact with extension service also have a negative sign although the coefficients are statistically insignificant for the latter. The implication is that households with higher education level and trained farmers have more knowledge on crop management and input use and thus are more likely to handle pesticides with more caution. In line with our expectation, households with higher access to facilities experience significantly less incidence of acute illness as indicated by the negative coefficient of facility index[8].

Most importantly, the regression analyses clearly demonstrate the substantial role of adoption of EU private standards in reducing incidence of acute illness associated with pesticide use. With all other factors in the model held constant, farmer who adopt GlobalGAP standards experience about 70% lesser incidence of acute illness compared to non-adopters farmers. The results demonstrate that the adoption of emerging standards confer a positive externality effect on adopters and may serve as a means to transform the production systems that contribute to better health for the producers in developing countries.

Eating in the vegetable field while spraying tend to increase substantially the incidence of acute illness perhaps due to the fact that there might be no availability of water in the field to wash hands and food before eating, which will increase the direct contact with pesticides. Contrary to the findings of

[8]We also performed a test to detect the problem of multicollinearity between BATH & FACI using a technique of Variance Inflation Factor (VIF). The results show that there is no strong correlation among the variables since the values of VIF are by far less than 10.

Okello and Swinton (2006) taking a bath after spraying chemicals does not significantly reduce the incidence of poisoning. Results of Ohayo-Mitoko (1997) also show that farmers bath after spraying chemicals as a reactive behavior rather than preventive measure. As expected total number of hours spent on chemical spraying by household member is significant and positively correlated with the incidence of health symptoms within the household. This is perhaps due the fact that household members are more likely to experience direct pesticide exposure. The safe use of pesticides has often been considered a pivotal aspect in mitigating episodes of pesticide poisoning (Cropper 1994; Atkin *et al.*, 2000). Studies conducted by Murphy, (1999), Ajayi, (2000) and Mancini, (2005) have demonstrated that farmers from developing countries use pesticide in unsafe and hazardous manner, describing mixing pesticides with bare hands, lack of protective clothing, using leaking backpack sprayers and storing pesticides in kitchens or bedrooms, which enhanced the health risk of pesticides. The four district dummies controlling for agro-ecology and differences in institutional settings are significant in three instances. Export farmers in Muranga, Nyeri and Makueni districts experience significantly high cases of pesticide ascribed health symptoms compared to the reference district, which is Meru district. Perhaps the cooler climate in Meru district might play a role in reducing pesticide exposure, with farmers wearing thicker clothes and less evaporation of the pesticides.

Results of cost of illness model

Table 3 presents results of factors determining cost of illness among export vegetable producers in Kenya. Test results of the model show that the assumptions of normality and homoskedasticity of the error terms are violated. Thus robust standard errors are estimated using White's heteroskedasticity consistent standard errors. The F-statistic of the excluded instruments is greater than 10 for the first stage adoption model, thus passing the test for weak instruments. The two instruments work well according to the Hansen specification test of overidentifying restrictions.

Table 3 here

The costs of illness are overwhelmingly explained by adoption of GlobalGAP standards as indicated by the negative and significant coefficient of adoption variable (ADOP) in the three econometric models pointing to the robustness of the results. Adoption of GlobalGAP standards decreases cost of illness by about 60% compared to non-adopters in the two-stage treatment effect model whereas about 50% on average in the regression based on propensity score.[9] This result

[9] When dummy variables are used in a model with a log-transformed dependent variable, the coefficient of the dummy variable multiplied by 100 is not the usual percentage effect of that variable on the dependent variable (Kennedy, 1981).

corroborates with the earlier results that underscore the negative correlation between adoption of standards and the incidence of acute health symptoms. Costs of illness seem to decrease with age of the household head although at an increasing rate as can be seen from the coefficient of the age squared. Female-headed households incur significantly lower health cost compared to their male-headed counterparts perhaps due to their limited role in pesticide handling in the study area. Facility index is negative and statistically significant (at 5%). This could perhaps be explained by the fact that farmers with better access to facilities have experienced lower incidence of acute illness as presented before and this is translated to lower cost. On the other hand total income of the household during 2005 cropping season is positively correlated with the cost of illness although the coefficient is not significant[10].

More educated and highly skilled households are expected to experience lower cost of illness and the result supports this notion. Human capital related variables such as education status of the head, level of agricultural training and number of contacts with extension personnel's all have a negative impact on health cost attributed to pesticide use although the coefficients is not significant for the former. In line with our expectation, pesticide exposure related variables have their expected signs. Eating in the vegetable field while spraying chemicals significantly increase the health cost however the coefficient of the number of hours sprayed is not significant in the model. Quite surprisingly, the coefficient of years of alcohol intake displays a negative sign and significant, whereas year of smoking does not seem to affect cost of illness though positively correlated. Perhaps drinkers prefer to spend their money on alcohol rather than on medicine.

With respect to the quantity of different class of pesticide use, hazard category pesticide type I and II are found to be significantly explaining the cost of illness among export producers, which is not surprising given that they are classified as highly toxic. Out of the four district dummies included in the model to control for agro-ecology and other institutional settings, two of them are found to be significant. The results display that farmer in Meru district experience significantly low cost of illness compared to farmers in Nyeri and Muranga districts, perhaps for the same reason stated earlier.

Instead it should be calculated as: $h = 100 * \left[\exp(\beta_i - 1/2v(\beta_i)) - 1\right]$ where h is the percentage change in the level of the dependent variable, β_i is the estimated coefficient of the dummy variable and $v(\beta_i)$ is the estimated variance of β_i, which is applied in this study.

[10] Prior to running the model, a test is conducted to detect the problem of multicollinearity between facility index and total annual household income and we found no strong correlation between the variables. We also run the model excluding the income variable but the signs and significance level of other variables didn't change.

5. Conclusions

This study contributes to the growing literature on the implications of introducing food-safety standards in developing countries for farmers' health, using the case of Kenyan export vegetable producers. The primary aim of this paper is to empirically investigate whether adoption of EU private food-safety standards confer positive externalities in terms of improved health using econometric modeling.

Results show average cost of pesticide-related health risks at about 165 KSh and 324 KSh per cropping season for GlobalGAP adopters and non-adopters export producers, respectively. These costs equal 86.4% of the mean household chemical expenditure per cropping season for non-adopters and 39.6% of those adopters. Compared to the results obtained in other studies (Rola and Pingali, 1993) the ratio of health cost to pesticide cost presented in this paper is conservative since the computation of health costs is based on the actual market cost of direct short term health impairments and it does not refer to the costs to restore farmers' health status completely as followed by Rola and Pingali (1993) and Garming and Waibel (2008). Even when the amount of pesticide used might have been insufficient to cause acute health hazards, chronic hazards might also occur through low dosage use over a long time period. Estimation results also show that adoption of GlobalGAP standards has a positive and significant impact on farmer's health both in terms of reduction of pesticide related acute poisonings and its associated cost of illness. Farmer's who adopt standards experience 70% lesser incidence of acute illness and spent about 50-60% less on restoring the damaged health compared to non-adopters. On the other hand incidence of pesticide-related acute illness symptoms and its associated health cost increase significantly with the use of highly toxic pesticides. Eating in the vegetable field while spraying substantially increases the pesticide poisoning and cost of illness. Human capital proxies such as education level of the head, knowledge of pesticide labels, level of agricultural training and contact with extension service also tend to decrease the incidence of acute illness. These indicate the need for farmer education in exposure averting strategies.

Generally, the empirical results presented in this paper support the notion that the adoption of emerging food-safety standards can play a positive role by serving as a catalyst for transforming production systems towards safer and more sustainable operation and resulting in better health for farmers aside from those that accrue for consumers in industrialized countries. Nevertheless, in order to extrapolate these results to the whole export vegetable sector in Kenya, it is crucial to look closely at the scale of adoption of standards nationwide. According to data from FoodPlus secretariat, the legal body of GlobalGAP, and a separate survey by Mithöfer *et al*. (2008), the scale of adoption among export vegetable producers seems to be rather low (i.e. below 20%) for achieving a direct significant impact within the smallholder vegetable export sector. Our data suggest that about 33% of the sampled households adopted the standards during the survey season though this may not necessarily reflect the rate of adoption.

In previous farm-level analysis of determinants of GlobalGAP adoption in Kenya (Asfaw *et al.,* forthcoming), we identified lack of human capital (e.g. level of education of household members), physical capital (e.g. farm machinery) and social capital (e.g. group membership) as major determining factors that limit the adoption of standards by smallholders. The government and the private sector can help farmers to expand and upgrade their range of assets and practices to meet the new requirements of supermarkets and other coordinated supply chains. The options include public investment in increasing farmers' productivity and connectivity to markets, and promotion of collective action and the building of the technical capacity of farmers to meet the new standards.

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Table 1. Descriptive summary of variables used in estimations (N = 439)

Variables	Unit	Adopters (N = 149)	Non-adopters (N = 290)	t-stat[a] (chi-square)
Dependent variables				
Acute pesticide poisoning cases (**ACUT**)	count	1.61	2.21	1.74*
Health cost of illness (**COST**)	KSh	165.54	324.33	2.42**
Household characteristics variables				
Age of the household head (**AGEH**)	years	45.38	46.18	0.53
Age square (**AGSQ**)	years	2,212.41	2,297.23	0.57
Male household head dummy (**GEND**)	1/0	0.89	0.81	3.57*
Highest grade attained by household head only (**EDU1**)	years	9.42	8.07	-3.28***
Highest grade attained by other adult household members (**EDU2**)	years	9.77	8.89	-1.67*
Household wealth variables				
Total annual income (**INCO**)	KSh	144,141	148,100	0.11
Total land size (**LAND**)	acres	2.97	2.66	-0.99
Facility index (**FACI**)	-	1.59	1.03	-5.68***
Pesticide exposure and health related variables				
Hazard Category I pesticide (**PES1**)	gram	13.06	29.64	2.32**
Hazard Category II pesticide (**PES2**)	gram	64.21	74.32	1.06
Hazard Category III pesticide (**PES3**)	gram	105.41	100.42	-0.17
Hazard Category IV pesticide (**PES4**)	gram	156.26	99.96	-2.96***
Use cocktail of chemicals dummy (**COCK**)	1/0	0.59	0.77	10.89***
Bath after spraying dummy (**BATH**)	1/0	0.99	0.93	5.49**
Eat while spraying dummy (**EATE**)	1/0	0.12	0.02	14.67***
Knowledge on the label of pesticide dummy (**LABE**)	1/0	0.96	0.89	4.47**
Number of hours sprayed by family members (**HRSP**)	hours	8.57	11.24	2.21**
Smoking duration (**SMOK**)	years	2.34	3.89	1.62*
Alcohol intake duration (**ALCO**)	years	1.32	2.42	1.44
Institutional and access related variables				
Radio use per week **(RADI)**	hours	27.82	25.36	-1.42
Number of major agricultural training subjects attended (**TRAI**)	count	6.81	5.26	-3.61***
Contact with extension service dummy (**EXTE**)	1/0	0.86	0.73	6.25**
Amount of credit used for the past three years prior 2005 (**CRED**)	KSh	5,535	4,459	-0.55
Number of years the head has been a group member (**GROU**)	years	3.15	1.33	-5.83***
Number of years the head has been involved in formal contract (**CONT**)	years	2.66	2.30	-1.18

[a] Statistical significance at the 0.01 (***), 0.05 (**) and 0.1 (*) level of probability.

Table 2. Determinants of self reported acute symptoms of pesticide poisoning among export vegetable producers –Two-stage Poisson regression results (N=439)

Dependent variable: Count of total acute pesticide symptoms per cropping season

Variable	Estimated [a] Coefficient	Murphy-Topel Standard Error	t-value
Constant	3.412	2.662	1.50
AGEH	-0.157*	0.083	-1.83
AGSQ	0.002**	0.000	2.03
GEND	0.879**	0.441	2.20
EDU1	-0.037*	0.024	0.172
FACI	-0.444*	0.243	-1.90
PES1	0.008**	0.003	1.87
PES2	0.003*	0.002	1.80
PES3	0.002	0.004	1.35
COCK	0.612	0.522	1.327
BATH	-0.572	0.893	-0.77
EATE	0.922***	0.421	3.23
LABE	-0.911***	0.323	-2.44
HRSP	0.024*	0.020	0.171
SMOK	0.043*	0.023	1.81
ALCO	-0.182**	0.069	-2.32
TRAI	-0.122**	0.044	-2.07
EXTE	-0.258	0.321	-0.73
DISTRICTS			
MERU (reference)			
KIRINYAGA	-0.651	0.492	1.58
MURANGA	2.327***	1.134	5.02
NYERI	0.954**	0.468	2.16
MAKUENI	1.000*	0.512	1.92
ADOP	-0.692**	0.365	2.54
Log pseudo-likelihood		-164..845	
Pseudo R2		0.343	
Wald Chi2 / Prob > Chi2		188.43 / 0.000	
Test of instruments -			
F test (first stage)		10.34	
P-value		0.00	
Test of Overidentification			
Chi-square		0.77	
P-value		0.38	

[a] Statistical significance at the 0.01 (***), 0.05 (**) and 0.1 (*) level of probability

Table 3. Estimation results of cost of illness associated with pesticide poisoning (N=439)

Dependent variable: Natural log of farmer's health cost of pesticide intoxication in KSh

	Two-stage standard treatment effect model		Regression based on propensity-score			
			without control variables		with control variables	
Variable	Estimated [a] Coefficient	Rob. Stand. Error	Estimated [a] Coefficient	Rob. Stand. Error	Estimated [a] Coefficient	Rob. Stand. Error
Constant	2.096**	0.843	-0.053	0.086	2.011**	0.811
AGEH	-0.051*	0.044			-0.056*	0.035
AGSQ	0.001*	0.000			0.001*	0.000
GEND	0.169*	0.099			0.192*	0.110
EDU1	-0.018	0.014			-0.011	0.009
INCO	0.001	0.000			0.001	0.000
FACI	-0.241**	0.089			-0.148*	0.101
PES1	0.006***	0.000			0.010***	0.000
PES2	0.003*	0.000			0.005*	0.000
PES3	0.001	0.003			0.002	0.001
COCK	0.120	0.091			0.141	0.088
BATH	0.011	0.269			0.016	0.301
EATE	0.384**	0.010			0.406***	0.009
LABE	-0.212**	0.132			-0.247**	0.122
HRSP	0.006	0.014			0.005	0.019
SMOK	0.011	0.006			0.015	0.007
ALCO	-0.017**	0.010			-0.020*	0.009
TRAI	-0.029*	0.015			-0.022*	0.021
EXTE	-0.218*	0.136			-0.148	0.139
MERU (reference)						
KIRINYAGA	-0.150	0.175			-0.198	0.186
MURANGA	0.904***	0.294			0.922***	0.301
NYERI	0.124	0.196			0.229	0.197
MAKUENI	0.872**	0.521			0.787*	0.450
ADOP	-0.619***	0.144	-0.452**	0.128	-0.538**	0.117
Pscore			0.257*	0.266	0.298*	0.254
Log pseudo-likelihood		-543.871				
Wald Chi2 / Prob > Chi2		209.391 / 0.000				
F-test/ Prob > F				3.65 / 0.000		6.33 / 0.000
R-squared / adj. R-squared				0.13 / 0.11		0.33 / 0.26
Test of instruments -						
F test (first stage)		11.49				
P-value		0.00				
Test of Overidentification						
Chi-square		0.18				
P-value		0.67				

[a] Statistical significance at the 0.01 (***), 0.05 (**) and 0.1 (*) level of probability