The effect of developed-country pesticide standards on health and pesticide-induced morbidity of Kenya's green bean family farmers

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Introduction

Consumers in developed countries form the bulk of the market for high value fruits and vegetables from developing countries. Their demand for produce with specific physical attributes, especially spotlessness, has encouraged developing country growers of fresh export vegetables to rely increasingly on the use of pesticides to control pests (Thrupp, 1995). Increased use of pesticides in fresh export vegetables and the resulting widespread detrimental medical health and ecological effects on non-target plants and animals have been reported in Latin America by Thrupp (1995), and Africa by Mwanthi and Makau (1991), and (Ohayo-Mitoko, 1997). These reports have led to concerns over medical health and environmental effect of increased use of pesticides. In addition, the European food safety scandals of the last two decades have eroded consumers' confidence in existing food safety regulation (Freidberg, 2004, World-Bank, 2005) .

In order to protect consumers and farm workers from hazards of pesticide contamination and exposure and restore consumer confidence, developed-country governments have revised their food safety laws and placed responsibility for safety assurance on retailers. Major developed country retailers have responded by developing private codes relating to pesticide residue limits, hygiene and traceability that are often more stringent than official requirements. To enforce these standards developing country growers are intensely monitored under closely coordinated contracts. To be compliant farmers have to ensure that i) they only use approved pesticides (usually less toxic to humans than ones used before), ii) they produce beans that meet UK pesticide residue limits, iii) pesticides are applied only when pest scouting reveals the need to do so and iv) pesticides are handled, used, stored and disposed off in ways that do not pose health threats to farm workers and other non-target plants and animals.

Many previous studies have investigated a wide range of topics on pesticide use and farmer health in developing countries (Maumbe and Swinton, 2003; Antle and Pingali, 1994; Thrupp, 1995; Ohayo-Mitoko, 1997). These studies offer recommendations for domestic pesticides policy. No study has addressed the issue of developed country pesticide standards on developing country farmers. In theory, developed-country pesticide standards (DC-PS), if enforced, could reduce exposure of developing country farmers to toxic pesticides and hence their cost of pesticide-related illnesses. Unfortunately, there are no studies that focus on the effect of developed consumer nations' pesticide standards on developing country farmers' health and morbidity due to pesticides exposure. This paper addresses two research questions: i) What is the effect of developed-country pesticide standards on cost of illnesses associated with pesticide exposure? ii) What is the effect of these standards on how developing country farmers use pesticides?

This paper focuses on compliance with DC-PS in green beans produced by Kenyan family farmers for export to the United Kingdom (UK). Kenya is one of the leading exporters of green beans to the UK while major retailers in the UK have developed very stringent pesticide standards thus making a suitable case to study. We categorize green bean growers into two regimes: those whose buyers routinely monitor and enforce compliance with DC-PS comprise the "monitored" regime while those whose buyers don't monitor and enforce DC-PS compliance constitute the "unmonitored" regime.

Theoretical model

Consider a farm that grows vegetables for export and uses pesticides. A farm can produce under one of the two regimes, monitored or unmonitored. Pesticide use can affect the farmer's health status through pesticide-induced ailments. Following prior authors (Pingali, et al., 1994, Strauss and Thomas, 1998), the farmer's health status can be represented as:

(1) $h = h[f, b, e(x, d), z)]$

where h is the health status of the farmer; f is a vector of farmer-specific characteristics that impact health status (e.g., age, gender, education, income); b are behavioral factors (e.g., smoking and alcohol consumption); e is exposure to pesticides, $e = e(x,d)$, which depends upon x, a vector of pesticide inputs used by the farm and d a vector of defensive strategies, such as exposure averting behavior (e.g., use of protective devices) and exposure mitigating strategies (e.g. use of alternative pest management practices, hand-washing and water bath following pesticide handling and application). Lastly, z represents institutional factors such as access to extension services, pest management information and medical services.

The farm uses both pesticide and non-pesticide inputs to produce output represented as:

(2) $q = q[x, v, T, k, z]$

where q is the output of vegetables, x is a vector of pesticide inputs, v are non-pesticide inputs such as land and fertilizer; T is the total effective field labor requirement comprising effective family labor, $l(h)$, (which depends on health impairment due to pesticide exposure) and hired labor, (r). Following Antle and Pingali (1994), we assume that the hired labor bears the cost of health impairments due to exposure to pesticide via inability to work when sick. Finally, k and z are fixed capital inputs and institutional factors, respectively. Output, output price and the vector of non-pesticide inputs are assumed predetermined, since DC-PS compliant vegetables are produced under contract (Jaffee and Masakure, 2005).

The farmer's optimization problem therefore is to choose x and d to minimize the combined health and production costs, i.e.,

$$\text{(3)} \qquad \underset{x,d}{Min} \quad c(x,d) = w_x x + w_d d$$

subject to labor availability ($T = l(h) + r$) and contracted output level ($q \geq q^0$). We assume that the cost and production functions are concave and that $h_e < 0$, $e_x > 0$, $e_d < 0$, and $l_h > 0$. Solving the Lagrangean expression associated with this cost minimization problem yields the input demand functions (Okello, 2005)

$$w_x = d\,\frac{\partial q}{\partial x} + d\,\frac{\partial q}{\partial l}\frac{\partial l}{\partial h}\frac{\partial h}{\partial e}\frac{\partial e}{\partial x} + l\left(\frac{\partial l}{\partial h}\frac{\partial h}{\partial e}\frac{\partial e}{\partial x}\right) \text{ and } w_d = d\left(\frac{\partial q}{\partial l}\frac{\partial l}{\partial h}\frac{\partial h}{\partial e}\frac{\partial e}{\partial d}\right) + l\left(\frac{\partial l}{\partial h}\frac{\partial h}{\partial e}\frac{\partial e}{\partial d}\right).$$

The first expression indicates that ignoring the health effects of pesticide exposure overestimates the marginal revenue of pesticides. The second expression implies that the optimal level of defensive strategies therefore depends on labor availability, pesticide exposure and farmer health status. In sum, optimal pesticide use entails lower health risks, which can be achieved by i) using less toxic pesticides or ii) employing more protection from pesticide exposure.

Since the use, storage and disposal of pesticides by compliant farmers are intensely monitored by their buyers who also demand use of adequate protection from pesticide exposure (Okello, 2005), we hypothesize that i) monitored farmers will incur lower pesticide-induced health costs than the unmonitored farmers, and ii) monitoring farmers for compliance with DC-PS will induce greater use of pesticide exposure protective devices.

Data and empirical methods

This paper uses data collected during 2003/2004 via personal interviews with 181 Kenyan green bean family farmers stratified by compliance with DC-PS. Health information was obtained by first asking the farmer to recall experiencing eye, skin and or stomach irritations soon after mixing/applying pesticides on green beans. For each symptom experienced information on the number of occurrences, days of sickness, number of visits to a local dispensary, cost of treatment per visit, travel expenses as well as costs of self treatment (e.g., buying over-the-counter medication, milk, or soup) was obtained. Based on the reported pesticide used, pesticide toxicity was looked up from the World Health Organization (WHO) toxicity classification as class 1 (very toxic), class 2 (toxic), class 3 (slightly toxic) and class 4 (unharmful) (World Health Organization, 2005). The WHO class 4 pesticides were omitted from further analysis because they do not present health hazards to users. Time lost due to pesticide related illnesses was converted into monetary values using market wage rate. Table 1 summarizes the data.

Table 1: Definition and summary statistics of the variables used in empirical estimations

Variable	Monitored regime		Unmonitored regime	
	Mean	Std Dev	Mean	Std Dev
Dependent variables				
Health cost (Kshs)*	185.6	253.3	260.6	246.7
Protective devices (count)	3	1	1	1
Farmer specific and institutional variables				
Farmer's age (years)	39.9	11.2	37.3	12.1
Male farmer (0,1)	0.8	0.4	0.8	0.4
Education (years)	8.4	3.5	10.0	2.9
Alcohol intake (years)	6.6	10.4	5.1	8.4
Cigarette smoking (years)	10.5	18.0	9.7	16.4
Exposure enhancing variables				
Class1 pesticides (grams)	39.6	388.4	84.5	512.0
Class2 pesticides (grams)	711.3	978.2	749.4	864.5
Class3 pesticides (grams)	263.2	620.4	551.4	1436.1
Eat spraying (0,1)	0.2	0.3	0.1	0.3
Drink spraying (0,1)	0.2	0.4	0.1	0.3
Primary applicator (0,1)	0.5	0.5	0.6	0.5
Skin contact (0,1)	0.8	0.4	0.9	0.4
Exposure averting and mitigating variables				
Wind direction (0,1)	0.6	0.5	0.7	0.5
Wash gear (0,1)	0.7	0.5	0.7	0.5
Change clothing (0,1)	0.2	0.4	0.2	0.4
Sprayer maintenance (count)	1.0	1.5	0.6	1.3
Sprayer inspection (0,1)	0.9	0.2	0.9	0.6
Label literacy (count)	0.6	1.4	0.2	0.3
Sprayer leaks (0,1)	0.3	0.4	0.7	0.7

* The exchange rate in 2003/04 was 78 Kenya Shillings (Kshs) to 1US$

This paper empirically tests the above hypotheses using survey regression, with *village* as the primary sampling unit, in order to account for the clustering effect within the villages. Two empirical models (unrestricted and restricted models) models are estimated in testing each hypothesis. In the unrestricted model, variables are included based on theoretical expectations. In the restricted model, however, we drop the practices variables most emphasized under the DC-PS (namely, pest scouting, sprayer maintenance, and use of protective gear) since their inclusion alongside the regime variable results in "double counting" (Okello, 2005). In addition, we use Wald test for joint exclusion of variables, to drop variables that add little information to both models.

The empirical model used in testing the effect of DC-PS on health cost (*hc*) of pesticide exposure is specified as:

(4) *hc = hc (age, male, education, alcohol intake, cigarette smoking, distance to clinic, regime, class1 pesticides, class2 pesticides, class3 pesticides, primary applicator and primary mixer, wash gear, gear items used, pest scouting, change clothing, sprayer maintenance).*

Since health cost is a continuous variable, the model is estimated using survey regression.

The hypothesis that DC-PS increases the use of protective devices (*prodev*) is tested using the following empirical model:

(5) *prodev = prodev(male, age, education, income, alcohol intake, cigarette smoking, plot size, regime, primary pesticide mixer, primary applicator, class1 pesticides, class2 pesticides, class3 pesticides, label literacy, eat spraying, sprayer leaks, skin contact, gear too costly, gear discomfort, gear slows work, pest scouting, sprayer maintenance, change clothing, bathes after spraying, wind direction),*

where *prodev* is a count of the number of protective devices used by the farmer. Since the dependent variable is count variable, survey Poisson regression technique is used in estimating equation (5).

Results

Contrary to expectations, the types and quantities of pesticides used by monitored and unmonitored green bean growers in Kenya showed little difference. For instance a few monitored farmers used WHO class 2 “toxic” fungicides in their last crop of green beans, while their unmonitored counterparts used none. In addition, monitored farmers used higher rates per acre of WHO class 1 “highly toxic” insecticides, albeit on fewer total acres and hence in less total quantity than unmonitored farmers.

Two factors may have lead to the lack of difference in pesticide use by monitored and unmonitored farmers. First, exporters who monitor and enforce compliance with DC-PS place a lot of emphasis on physical appearance of green beans, which implicitly encourages chemical control of pests and diseases. Spotlessness is the first attribute by which green beans are graded against. Second, some unmonitored farmers have benefited from previous training by Kenya government on safe use of pesticides while others are following DC-PS practices through a demonstration effect.

Effect of DC-PS monitoring and enforcement on pesticide-related cost of illness

The results of the cost of illness models are presented in Table 2. The restricted model shows that enforcing compliance with developed-country pesticide residue standards significantly reduces pesticide related health costs. The direction of effect of most variables in the two models is the same, indicating that the results are robust. However, the *regime* variable is insignificant in the unrestricted model, presumably due to the “double counting” effect discussed above. The proceeding discussion is therefore based on the restricted model.

Table 2: Determinants of pesticide-related health costs among Kenyan green bean growers, 2004 - survey regression

Dependent variable: Natural log of farmer's health costs* of pesticide exposure

Independent variables	Unrestricted model		Restricted model	
	Coefficient	p-value	Coefficient	p-value
Farmer specific and institutional variables				
male	-0.488	0.446	-0.537	0.419
log age	-1.603	0.029	-1.486	0.031
education	-0.150	0.083	-0.176	0.024
log income	0.468	0.405	0.045	0.069
log clinic	-0.463	0.031	-0.552	0.018
cigarette	-1.020	0.074	-0.834	0.091
alcohol	0.837	0.057	0.858	0.069
regime	-0.525	0.144	-0.870	0.014
Exposure enhancing variables				
log class 1 pesticides	0.045	0.689	0.045	0.664
log class 2 pesticides	-0.025	0.891	-0.033	0.870
log class 3 pesticides	-0.037	0.491	-0.025	0.658
primary mixer	1.587	0.003	1.728	0.001
primary applicator	0.478	0.294	0.302	0.541
Exposure averting and mitigating variables				
wash gear	-0.858	0.009	0.710	0.044
change clothing	-0.859	0.076	-1.085	0.032
gear items worn	-0.219	0.015	--	--
pest scouting	-1.022	0.028	--	--
sprayer maintenance	-0.121	0.524	--	--
constant	7.281	0.085	7.167	0.008
F statistic	13.780		5.970	
p-value	0.000		0.001	
R-squared	0.291		0.235	
N	175		175	

* Where health cost was zero, we added 0.5 to facilitate taking the natural logs

As anticipated, the *regime* variable in the unrestricted model is insignificant, presumably because its effect is overshadowed by inclusion of the same practices it should capture. The restricted model shows that enforcing compliance with DC-PS significantly reduces pesticide related health costs. Education, distance to health facility and income also affect health costs. An additional year of education reduces health costs of pesticide exposure by close to 18 percent. Results show also that the elasticity of health cost with respect to distance to health clinic is -0.552, indicating that proximity to clinic reduces health costs of pesticide induced illnesses. On the other hand, the elasticity of health cost with respect total family income is 0.045, indicating increase in family income increases the share allocated to medical care. This finding is in line with existing literature suggesting that health is a luxury good in developing countries (Mcguire and Serra, 2005). In addition, the restricted model shows that primary pesticide mixers incur higher health costs. While not surprising, it corroborates Harper and Zilberman's (1992) findings for the US agriculture.

Among the exposure mitigating and averting strategies, the restricted model shows that pesticide applicators who change clothing contaminated by pesticide leak and wash off the pesticides from their bodies (*change clothing*) experience lower cost of pesticide illness than those who don't, presumably because they reduce duration of skin contact with pesticides. However, washing the gear before next use (*wash gear*) increases the cost of pesticide related sickness. While this is contrary to expectations, it may be indicative of exposure to pesticides during the washing of contaminated clothing.

Effect of enforcing DC-PS compliance on the use of protective devices

The use protective devices (especially the protective gear) stands out as one of the main pesticide exposure averting practices that is significant in reducing the cost of pesticide-related morbidity among green bean growers in Kenya. Does enforcement of developed-country pesticide residue standards affect the use of these devices? The results of unrestricted and restricted empirical models estimated to address this question are presented in Table 3. For the same reasons discussed above, we limit our discussion to the restricted model. As hypothesized, monitoring and enforcement of the developed-country pesticide standards do have significant effect on the number of protective gear items used by green bean growers. Other factors being equal, monitored farmers use more gear items than the unmonitored farmers as shown by the restricted model. Results also show that elasticity of number of gear items used with respect to age is -0.300, which implies that older people use less protective devices. This finding may however be because spraying is normally done by younger people, especially men.

Among the pesticide exposure enhancing practices, label literacy and eating food during pesticide application affect the use of protective gear. In particular, label literacy increases the number of gear items used. An additional color-band of the pesticide label correctly interpreted by the farmer increases the number of gear items used by the farmer by about 8 percent. In line with previous studies (Pingali, 1995), restricted model further shows that the costliness of the protective gear, the discomfort of using it especially in hot tropical climate, and the feeling among farmers that using full gear slows the speed of spraying individually reduce the number of protective gear items used by green bean growers.

Table 3: Determinants of the number protective gear items among Kenyan green bean growers, 2004, survey Poisson regression

Dependent variable: Number of items of the protective gear used by the farmer

Independent variables	Unrestricted model		Restricted model	
	Coefficient	p-value	Coefficient	p-value
Farmer specific and institutional variables				
male	-0.101	0.556	-0.069	0.657
log age	-0.341	0.049	-0.300	0.069
education	0.025	0.499	-0.012	0.892
log income	-0.015	0.753	-0.009	0.819
alcohol intake	-0.085	0.785	--	--
cigarette smoking	-0.020	0.120	--	--
plot size	-0.020	0.053	-0.010	0.314
regime	0.722	0.000	0.749	0.000
Exposure enhancing variables				
primary pesticide mixer	0.203	0.244	0.159	0.312
primary applicator	-0.069	0.635	-0.112	0.364
log class 1 pesticides	-0.054	0.190	-0.044	0.270
log class 2 pesticides	0.021	0.411	0.022	0.431
log class 3 pesticides	0.003	0.866	0.005	0.747
label literacy	0.068	0.033	0.083	0.003
eat spraying	0.201	0.105	--	--
sprayer leaks	-0.164	0.470	--	--
skin contact	-0.083	0.540	--	--
Exposure averting and mitigating variables				
gear too costly	-0.252	0.029	-0.305	0.024
gear discomfort	-0.277	0.022	-0.245	0.005
gear slows work	-0.459	0.035	-0.543	0.005
pest scouting	0.106	0.393	--	--
sprayer maintenance	-0.066	0.085	--	--
change clothing	-0.145	0.542	--	--
washes gear before next use	-0.004	0.975	--	--
bathes after spraying	-0.059	0.719	--	--
observes wind direction	-0.004	0.958	--	--
constant	1.819	0.121	1.715	0.060
N	175		175	
F statistic	4.42		11.43	
p-value	0.201		0.000	

Source: Author’s survey, 2004

Conclusions and Policy Implications

This study contributes to growing literature on pesticide use on farmer health by looking at the effect of developed-country pesticide standards on farmers' cost of pesticide-related illnesses and use of defensive strategies. It demonstrates that private regulation of pesticide use through buyer enforcement of DC-PS coupled with education and pesticide safe use training available to monitored farmers work together to reduce cost of pesticide-related illness. This supports evidence from other developing countries indicating that effective solution of farmer health problems associated with pesticide use requires a combination of policies (Antle and Capalbo, 1995).

These findings imply that DC-PS standards have health benefits to Kenyan farmers beyond the acknowledged income gains from selling to the premium European produce market. The findings of this study therefore refute the common argument by exporting country governments that DC-PS have no tangible benefits to farmers (Murimi, 2004). One area of future research would be to investigate to what extent the "good practices" promoted under DC-PS spill over into production of domestically marketed produce such as tomatoes which normally requires heavy use of pesticides and whether monitored farmers obtain the same benefits when growing tomatoes and other export crop.

This study also demonstrates the importance of education and literacy in promoting the use of protective gear (hence safe use and handling of pesticides), which in turn reduces exposure to toxic pesticides, the accompanying incidence of pesticide-related acute illnesses, and hence pesticide exposure health costs. The implication of this finding is that more effort should be directed at training farmers on safe use and handling of pesticides. Related to this are the findings of studies done elsewhere indicating that farmers who are informed about the health effects of pesticide exposure might hire pesticide applicators a defensive strategy. This aspect of the effects pesticide exposure on farm workers' health was not investigated in this study due to lack of information. Future research should therefore specifically investigate if some farmers hire pesticide applicators as way of protective themselves from the pesticide induced illnesses.

Finally, the finding that DC-PS has health benefits to farmers presents an opportunity for the Kenya government to work with exporters to reduce the health hazards of pesticide exposure among growers of export vegetables. In particular, the government should target unmonitored farmers who still use large quantities of toxic chemicals. Providing institutional support needed to mobilize farmers into farmer groups and linking the groups with exporters while also encouraging exporters to enforce DC-PS would be one way to get unmonitored farmers to use and handle pesticides judiciously while connecting them to attractive marketing opportunities.

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