HIDDEN HEALTH COSTS OF PESTICIDE USE IN ZIMBABWE'S SMALLHOLDER COTTON[1]

by

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Abstract:

Hidden Health Costs Of Pesticide Use in Zimbabwe's Smallholder Cotton

Balancing the numerous benefits that may accrue from pesticide use on cotton, farmers face health hazards. Pesticide-induced acute symptoms significantly increased the cost of illness in a survey of 280 smallholder cotton growers in two districts of Zimbabwe. Cotton growers lost a mean of Z$180 in Sanyati and Z$316 per year in Chipinge on pesticide-related direct and indirect acute health effects. These values are equivalent to 45% and 83% of annual household pesticide expenditures in the two districts. The time spent recuperating from illnesses attributed to pesticides averaged 2 days in Sanyati and 4 days in Chipinge during the 1998/99 growing season. These pesticide health cost estimates represent lower bounds only; they omit chronic pesticide health effects as well as suffering and other non-monetary costs.

Acute pesticide symptoms were determined in large part by pesticide use practices, notably the lack of protective clothing. Yet many smallholder farmers misunderstood pesticide health hazards, and so did little to protect themselves. Despite the use of simple color codes, 22% of smallholder cotton growers in Sanyati and 58% in Chipinge did not know how to order the four colored pesticide label triangles by toxicity. Better farmer education in exposure averting strategies is needed. Likewise, fuller accounting for hidden health costs in future would allow farmers to make more informed decisions about agricultural pest management.

Keywords: pesticide, occupational health, cost of illness, agriculture, cotton, Zimbabwe

HIDDEN HEALTH COSTS OF PESTICIDE USE IN ZIMBABWE'S SMALLHOLDER COTTON

Among the inhabited continents, Africa's farms receive the smallest applications of agro-chemicals. But African cotton is an exception abundantly treated with fertilizers and pesticides. Hence, while the under-use of agrochemicals poses sustainability problems for many crops in Africa, in cotton the relevant question is whether Africa faces the overuse use problems that have bedeviled farmers in the wealthier nations (Wossink et. al., 1998).

The health hazards of pesticide use are receiving increased attention globally (Burrows, 1983; Fernandez-Cornejo, 1994; van Emden and Peakall, 1996). In the developed countries, efforts to restrict the use of certain pesticides and promote alternative crop protection methods gained momentum soon after the publication of *Silent Spring* by Rachel Carson in 1962. An increasing number of studies highlight further the gravity of occupational health problems related to pesticide use (Harper and Zilberman, 1992; Hurley et. al., 2000; Sunding and Zivin, 2000).

Health risks in agricultural production are a growing problem facing Africa (World Bank, 2000; Ajayi, 2000). Distorted policies that subsidize pesticides worsen health hazards experienced in most African countries (Fleischer, 1999). Poor access to health services and a medical profession that lacks the ability to recognize pesticide-related morbidity raises further concerns (The Pesticide Trust, 1993). Consensus is rapidly growing that farmer health issues in Africa constitute a serious threat to development and have the potential to reverse gains made in agricultural growth (Binswanger and Townsend, 2000).

Research in both economics and medicine corroborates that occupational health problems in agriculture have received scant attention (Watterson, 1988; Smith et. al., 2000). Yet improved health enhances functionality and productivity (Strauss et. al., 1998). Studies conducted in the Philippines conclude that pesticide use has a negative effect on farmer health, while farmer health has a positive effect on productivity (Antle and Pingali, 1994). Similar findings about the health costs of pesticide use have emerged from studies in Ecuador and the United States (Antle et. al., 1998; Crissman et. al., 1994; Harper and Zilberman, 1992; Sunding and Zivin, 2000), but the evidence from Africa is thin.

The occupational health threat from pesticide use in the less developed countries (LDCs) is exacerbated by lax environmental laws and poor access to complex pesticide information (WHO, 1990; Tjornhom et. al., 1997; The Pesticide Trust, 1993). The risk of exposure is worsened by farmer illiteracy (Kiss and Meerman, 1991), unavailable or unaffordable protective equipment, and missing health insurance markets in most poor nations (Antle and Capalbo, 1994; World Bank, 2000).

Although the problem is acknowledged, the extent of the health problems among farm workers in Africa remains unclear. Few African countries keep statistics about pesticide poisonings and fewer yet track chronic pesticide health effects (World Bank 1996; Rother and London, 1998). Moreover, health impacts may take a long time to appear and could be difficult to trace back to specific pesticide or polluting source (Wossink, et. al., 1998)

In Africa, empirical studies in support of the link between pesticide use and farmer health are patchy. Nhachi and Loewenson (1996) looked narrowly at occupational health problems among commercial farm workers in Zimbabwe, but not among smallholders. In West Africa, a survey on pesticide-related occupational health effects found that the social cost of acute poisoning in cotton is substantial (Ajayi, 1999; Fleischer, et. al., 1998).

Why are pesticides used copiously on cotton? Cotton has been a remunerative cash crop in Africa for a century. Smallholders in Zimbabwe have been expanding their plantings steadily since majority rule arrived in 1980. But cotton crops in Zimbabwe are vulnerable to a wide range of insect pests (Chivinge, Sithole & Keswani, 1999). Cotton yield losses to uncontrolled pests in Africa have been estimated to range between 40 and 65 percent (Jowa, 1996; Zethner, 1995). So successfully managing pests is key to profitable cotton production in Zimbabwe and in Africa as a whole.

However, if the health effects of pesticide use are significant, smallholder cotton farmers may be overestimating the *net* benefits of pesticides. An increasing body of evidence suggests that the benefits of pesticides are obtained at a substantial cost to the society (Antle and Pingali, 1994; Antle et. al., 1998; Cole et. al., 1998; Pingali et. al., 1995; Crissman and Cole, 1994; Pincus et. al., 1999; 1996; Watts, 1993; WWF, 1998; Czapar et. al., 1998; WHO, 1990). Whether Zimbabwe's smallholder cotton farmers experience significant pesticide health hazards and, if so, how they might be addressed is the focus of this study.

This study examines the degree and determinants of acute pesticide health symptoms among Zimbabwe's smallholder cotton growers. The results are specific to Zimbabwe, but the analysis provides useful lessons for cotton growers in other African countries. By systematically measuring health costs from pesticide use and tracing the effects of farming practices that contribute to them, this study offers guidance for policies to enhance the sustainability of cotton production. In particular, this study addresses four key questions regarding the health effects of pesticide use by Zimbabwe's smallholder cotton growers:

1. How large are the health costs of pesticide use?
2. What factors are responsible for these costs?
3. What factors account for acute pesticide poisoning symptoms?
4. How might changes in pesticide management practices and policy mitigate these symptoms and their associated health costs?

METHODOLOGY AND DATA

The analysis begins with a statistical description of the pesticide-related health effects reported by farm households in the two study regions. These effects include both acute pesticide poisoning symptoms and chronic conditions that could be related to pesticide exposure. A conservative estimate of pesticide related health costs is calculated as the sum of both cash and selected non-cash costs, including (1) farmer medical treatment costs at clinics and private physicians, (2) an annual levy of Z$100[2] contributed to the local rural health facility and (3) the opportunity cost of work days lost to illness (estimated at the 1998/99 agricultural minimum wage of Z$1,400 per month or Z$58.00 per working day). Not included in the composite health cost are travel costs to the health facility, waiting time prior to treatment, the value of leisure forgone due to illness, the cost of home-based health care, and the cost of traditional healing strategies (which

[2] US$1.00 = Zim$38.00 at time of survey in 1998/99.

farmers were generally reluctant to divulge). We assume health costs of pesticide exposure to hired labor are borne by the hired workers themselves (Antle and Capalbo, 1994).

Empirical estimation of the heal cost and determinants of pesticide exposure

The conceptual model underlying the next three stages of econometric analysis is presented in Figure 1. The first stage involves the estimation of a cost of illness model to explain the principal factors affecting health costs among smallholder cotton growers. Having shown that acute pesticide poisoning symptoms are the most serious medical conditions affecting health costs, in the second stage, we examine the determinants of the acute illness episodes experienced by the pesticide applicators, seeking ones that are amenable to policy solutions. In the final stage, we examine determinants of the adoption of specific pesticide management practices in order to identify ways to reduce health hazards.

Cost of illness model

The explanatory factors for the model explaining health costs incorporate three broad classes of variables: those related to health, agricultural input demand, and general household and institutional conditions. The health variables include two health indices, various measures of pesticide exposure and toxicity, as well as other known voluntary health hazards, such as smoking and alcohol consumption. The "acute symptom cases" variable is a count of the acute pesticide-poisoning classes experienced by a household (including irritation to stomach, eye and skin, for a maximum of three). The acute symptom severity index is calculated as the sum of the products of each acute symptom class and the reported severity on a 4-level scale (0 = none, 1 = mild, 2 = severe, 3 = very severe), so it ranges from zero to nine.   Variable definitions and descriptive statistics are presented in Table 1.

Health-related variables also include the annual rates of pesticide use on each farm by class of pesticide toxicity, arranged by the label color in Zimbabwe (from the highly toxic purple, to toxic red, to mildly toxic amber). Binary factors related to the risk of pesticide exposure included a tendency for family workers to eat in the cotton fields, ignorance of label meanings, presence of a leaky sprayer, and the existence of hazardously stored pesticides. Finally, the duration in years of smoking and drinking by the household head were also included.

Another set of variables comes from the expected determinants of agricultural input demand – in this instance, the demand for cotton pesticides. These include the area and production levels of cotton, the type of pesticide sprayer used (knapsack or ultra-low volume), and farmer's disposition toward prophylactic spraying.

Household conditioning variables included age, gender, education, and whether or not the household head held formal employment or owned a radio at the time of the survey. Human capital variables included graduation from the integrated pest and production management (IPPM) program of a Farmer Field School, number of extension meetings attended in past year, first aid knowledge, and number of protective clothing items worn by household head when spraying cotton. Finally, the institutional variables included access to a borehole (offering potable water) and distance to the nearest health center.

Following Antle and Pingali (1994), the health cost function was modeled as a logarithmic form of the hypothesized determinant factors. The log-log cost function is parsimonious in parameters, can be interpreted as first order approximation to the true cost function, and is globally well behaved (Antle and Pingali, 1994).

$$
\begin{aligned}
Ln(Health\ Cost) = {} & \delta_0 + \delta_1 Ln(AGE) + \delta_2 (GENDER) + \delta_3 Ln(EDUCATION) \\
& \delta_4 Ln(ACUTE\ SYMPTOMS) + \delta_5 Ln(ACUTE\ SYMPTOM\ SEVERITY) + \\
& \delta_6 Ln(ALCOHOL) + \delta_7 Ln(SMOKE) + \delta_8 (BOREHOLE\ ACCESS) + \\
& \delta_9 Ln(HEALTH\ CENTER\ DISTANCE) + \delta_{10} (FIRST\ AID) + e
\end{aligned}
$$

Acute symptoms model

In order to understand the agricultural practices that affect pesticide poisoning, the second stage econometric analysis focuses on determinants of the number of acute symptoms of pesticide poisoning. In addition to the farm characteristic, institutional and ancillary health-related variables used in the health cost regression, a set of special variables were added to measure the likelihood of pesticide exposure, exposure averting and mitigating behavior, and the toxicity of pesticides used.

Pesticide toxicity was measured using the color code ranking defined by the Plant Protection Research Institute in collaboration with the Zimbabwe Hazardous Substance and Articles Control Board. Four pesticide hazard classes are distinguished by their color codes: green, amber, red, and purple, in rising order of toxicity. Surveyed farmers did not use any green label pesticides, so the analysis uses only three pesticide classes. Color codes are assigned based on three criteria, (1) the acute oral lethal pesticide dose (that kills half of a test animal population, i.e., LD_{50}), (2) the concentration of the formulation and (3) the persistence of the pesticide in the ecosystem (Nhachi, 1999). We focused on acute effects since these are health problems that occur very close to the time when one is exposed to the pesticides (Moses, 1992). Pesticide exposure is measured as a product of the active ingredients per application and the number of chemical applications made (Hornsby et. al., 1996; EPA, 1999).

The household's number of acute symptom incidences is estimated as a Poisson regression model. Of particular interest among the explanatory variables are those that relate to hazard-related practices that could be changed. These include exposure-inducing traits such as label illiteracy, taking meals in cotton fields, and use of leaky sprayers, as well as exposure-averting traits such as being an IPM training graduate, having knowledge of first aid, and wearing protective clothing. A full description of the variables used to estimate the model is presented in Table 1.

Pesticide safety practices

For those pesticide exposure-related practices that were significantly related to the number of reported acute pesticide poisoning symptoms in the Poisson model, a third stage of analysis sought to identify factors affecting the choice of those practices. The use of protective clothing, a particularly important practice, is reported here as indicative of a wider set of results from probit and Poisson models of pesticide exposure practices adoption reported more fully in Maumbe (2001).

The Poisson model of determinants of the number of protective clothing items worn includes many of the same variables included in the acute symptoms model. Because the expectation of illness is a relevant explanatory variable, but the actual level of illness incidence is partly endogenously determined by the wearing of protective clothing, predicted (rather than actual) values were included from models of acute pesticide skin and eye symptom incidence. Too few incidences of stomach poisoning occurred to be included. Other variables that were included in the protective clothing model but dropped in the symptom incidence model due to weak explanatory power are prophylactic spraying, distance to health center, and whether or not the cotton grower is master farmer certified. All other variables were similar to those in the acute symptoms Poisson model.

Data

Farm level data were obtained from a primary survey conducted from June to December, 1999, in two leading cotton-producing regions of Zimbabwe. The Sanyati district is located in the Middleveld (altitude 600-1200m), a region where smallholders have grown cotton successfully since the late 1960s. In order to assess the effect on pesticide exposure of special knowledge about pest management, the sample included clusters of villages with exposure to the Farmer Field School Integrated Pest and Production Management (FFS-IPPM) training program. Within those villages, farm households were stratified on the basis of farmer participation or non-participation in the FFS-IPPM program. The Chipinge district is located in the Southeastern Lowveld of Zimbabwe (altitude 300-600m), where cotton farming has been widespread for less than 15 years. The area has highly productive vertisol soils, but no FFS-IPPM program. Survey villages were chosen on the basis of relative distance from markets and farm size.

A single visit survey was used to gather primary data on field pest management practices and farmer-reported health status. Health variables included incidences, treatments and degree of severity of pesticide-related acute illnesses. The cotton pest management data collected included type of pesticide used, target insect, number of applications made in each cotton field, pesticide storage method, and pesticide disposal practices. Usable responses were obtained from a total of 280 growers, 140 in each of the two regions. The main incentive for participating in the survey was the certificate of participation awarded to farmers who completed the interview. All farmers gave informed consent prior to the interview.

RESULTS

Incidence of pesticide-related acute illness symptoms

Pesticide use in Zimbabwe's smallholder cotton production is associated with a range of reported acute pesticide poisoning symptoms (Table 2). Over half of farmers interviewed in both districts reported skin irritations, while more than a quarter reported eye irritation and 7-12% reported stomach poisoning. However, only 2-8% of these cases actually sought medical treatment. Various other pesticide-related symptoms were also reported, most notably dizziness in 10-20% of households. The lower symptom incidence levels among Chipinge farmers may result from lack of awareness of pesticide hazards as indicated by their lower label literacy. Although farmers were not asked to indicate the specific chemicals responsible for the reported acute symptoms, the common pesticides used on smallholder cotton and known to cause health problems include carbamates, organophosphates, organochlorines, and pyrethroids. The first two of these pesticide classes are commonly associated with risk of skin irritation and stomach poisoning (Cole, Carpio, Julian & Leon, 1998; WHO, 1990). Male farmers are the major risk group as they are responsible for most of the spraying.

For the 1998/99 season, the estimated average cost of pesticide-related health risks was Z$180 and Z$316 for Sanyati and Chipinge districts respectively. These costs equal 45% of mean household chemical expenditures in Sanyati and 83% of those in Chipinge. The health costs are assumed to be incurred by the pesticide applicators. True costs are likely to be much higher when taking into consideration 1) other members of the household are potentially exposed, 2) few pesticide-related symptoms received medical treatment, and 3) chronic pesticide exposure conditions, such as cancer, were omitted in this study for lack of longitudinal observations of pesticide use. Epidemiological studies elsewhere have linked certain types of cancer to pesticide use (Blair, Malker, Cantor, Burmeister & Wiklund, 1985; La Vecchia, 1989; Wigle, 1990). Factoring in these hidden costs likely reduces the net benefits of pesticides among growers considerably.

During the 1998-99 cotton season, farmers lost an average of 2 and 4 days recuperating from pesticide-induced illnesses in Sanyati and Chipinge, respectively. Although the average distance to the nearest health facility is 5km in Sanyati and 9km in Chipinge district, the proportion of farmers who visited the clinic to seek medical attention after acute pesticide poisoning or irritation was very low, about 3% in Sanyati and 7% in Chipinge (Table 2). The use of home treatments and prayer to end health ailments partly explain why farmers do not often seek medical assistance from health facilities in the study zones.

The significant incidence of pesticide-related illness symptoms and associated costs may be related to the toxicity of the cotton pesticides used, as well as practices that permit exposure to them. Table 3 shows that dangerous and very dangerous pesticides accounted for most of those used in Sanyati and a quarter of those used in Chipinge. The rest were all fell in the still poisonous “amber” category; none were in the more benign “green” category.

Although the pesticide toxicity color codes were designed for ease of use by illiterate farmers, 58% of farmers in Chipinge and 22% of those in Sanyati could not correctly order the four pesticide toxicity ranking color triangles (Maumbe, 2001).

Cost of illness model

Pesticide-related health costs are determined overwhelmingly by the number and severity of acute pesticide symptoms (Table 4). The elasticity of health costs with respect to acute symptoms was 0.16 in Sanyati and 0.29 in Chipinge. The results suggest that Chipinge cotton growers experience higher health costs per symptom than their Sanyati counterparts, likely due to their more remote location. The higher health costs could be due to greater exposure attributed to the rare use of protective clothing in Chipinge (34 % sprayed without protective gear) compared to Sanyati (only 4% reported using no protective clothing). The elasticity of health cost with respect to symptom severity shows a similar pattern at 0.09 in Sanyati and 0.12 in Chipinge.

Acute symptoms model

Given the critical contribution of pesticide-related acute symptoms to health costs, the second stage analysis investigated determinants of these symptoms using Poisson regression. The Poisson models show that pesticide-related acute symptoms in both districts increased with dosage of the most toxic pesticides, male farmers, larger farm sizes, and extension meetings attended (Table 5). That pesticide toxicity is closely related to pesticide-related acute illness is not surprising. Likewise, on larger farms where pesticides are applied over a larger area, applicators face more exposure risk. The gender effect is of interest for educational program targeting.

The finding that the number of extension meetings attended tends to increase the number of reported pesticide-related acute illnesses reported can be interpreted in various ways. It may be that extension meetings are focusing on chemical pest control without adequate safety precautions. That traditional extension services lack a health focus and need revitalization has been mooted in the literature (Sasakawa-Global 2000, 1999; Fleischer, 1999). Alternatively, if extension meetings are highlighting exposure risks and symptoms from pesticide poisoning, then growers who attended more extension meetings would be more likely to connect the skin, eye and stomach illness symptoms with pesticide exposure and to report them as such. Data on the content of extension meetings were unavailable to support one or the other of these explanations.

The incidence of acute pesticide-related illness symptoms in both districts was mitigated by knowledge of first aid and use of protective clothing. Likewise, the perception of pesticides as hazardous (embodied in the binary opinion variable that calendar spraying practices should be reviewed) also had a strong negative effect on reported acute symptoms. These factors jointly suggest an educational agenda to diffuse knowledge about pesticide risks, treatment of pesticide poisoning and prevention of pesticide exposure. Such an agenda might be targeted at the male farmers whose households suffered the most acute symptom incidences.

The “IPM graduate” variable was the one included in the Sanyati model that reflects training about pesticide use and associated risks (as well as non-chemical pest management). Surprisingly, this variable did not have a significant impact on reported acute pesticide-related illness symptoms. However, that result may be due to mixed effects from the training: a reduction of hazardous behavior combined with greater propensity to ascribe skin, eye and stomach symptoms to pesticide poisoning. The lack of an IPM training effect runs counter to evidence from Vietnam and West Africa showing that farmers practicing IPM had substantially lowered occupational health risks (Kenmore, 1997).

Protective Clothing Model

In order to understand why farmers engaged in practices that mitigated or averted pesticide symptoms, the third stage of the analysis looked at determinants of these behavioral practices. Pesticide risk averting behavior as indicated by the number of protective clothing garments owned consistently reduced pesticide-related health symptoms in both Sanyati and Chipinge. The Poisson regression analysis of the count of individual protective clothing items adopted by the farmers in the two districts revealed a number of differences between districts. However the effects of adult education and expected pesticide exposure symptoms were consistent in both districts (Table 6).

Both the number of extension meetings attended and graduation from the IPM training farmer field school contributed to the number of protective garments worn. This clear effect from adult education programs puts more weight on the charitable interpretation of these programs' effects in the acute symptoms model. That is, if extension and IPM training increase the number of protective garments worn, then their positive or nil effect on pesticide-related acute illness symptoms seems more likely to be due to informed farmers being more prone to recognize and report pesticide-related symptoms.

Contrary to expectations, the predicted number of acute skin burning symptoms had a strong, consistent negative effect on ownership of protective clothing (Table 6). While it is reasonable to expect that less protective clothing results in more skin symptoms, the expectation of more skin symptoms should lead to a greater attempt at self-protection. The evidence suggests a serious misapprehension on the part of cotton about the links between pesticide exposure and protective clothing. The evidence from

Chipinge also shows that those farmers who exhibit higher levels of pesticide label illiteracy are more likely to spray pesticides without adequate protective clothing.

CONCLUSIONS

Balancing the numerous benefits that may accrue from pesticide use on cotton, farmers face health hazards. Pesticide-induced acute symptoms significantly increased the cost of illness among Zimbabwean smallholder cotton growers in the two districts studied. Cotton growers lost a mean of Z$180 in Sanyati and Z$316 per year in Chipinge on pesticide-related direct and indirect acute health effects. These values are equivalent to 45% and 83% of annual household pesticide expenditures in the two districts. The average number of days spent recuperating from illnesses attributed to pesticides was 2 days in Sanyati and 4 days in Chipinge during the 1998/99 growing season.

The need for farmer education in exposure averting strategies is evident particularly in the new cotton region of Chipinge. Since Chipinge farmers face relatively greater exposure to pesticide risks than those in the established cotton region around Sanyati. Chipinge also has a higher proportion of farmers spraying without any form of protective gear. Although evidence from the traditional cotton producing zone of Sanyati suggests that farmer's participation in FFS-based IPM training does not significantly reduce the incidence of acute symptoms, awareness of IPM contributes to farmers' propensity to wear protective clothing while spraying pesticides.

Although the pesticide label contains information about pesticide hazards, it is ineffective for the many farmers who are illiterate. Despite the use of color codes, 22% of smallholder cotton growers in Sanyati and 58% in Chipinge failed to associate colored triangles to pesticide toxicity. Ignorance about pesticide toxicity prevalent among survey farmers ought to be seriously addressed by policy makers. Perhaps the use of local languages on labels for pesticides targeted to small farmers and educational campaigns about the dangers of pesticides could alleviate the situation.

A very small proportion of cotton growers in both regions reported that pesticide-related health problems resulted in a visit to seek medical attention to a local health facility. The evidence seems to suggest that some smallholders treat acute pesticide effects as minor side effects that do not warrant medical attention. The minimal use of formal health care services further suggests reliance on informal health care practices and adherence to religious values that discourage seeking medical treatment. This study corroborates finding by previous researchers that formal health statistics seriously under-report pesticide-induced acute symptoms, because most victims do not seek medical care (Chitemerere, 1996; Rother and London, 1998; WHO, 1990).

The importance of adult education – especially rural extension outreach programs – is highlighted by this analysis. Attendance at extension meetings is a significant determinant of both farmer adoption of preventative measures (like protective clothing) as well as being linked to the reporting of acute pesticide illness symptoms. The study shows ample evidence of both ignorance of crucial health hazard information (e.g., interpretation of pesticide hazard labels) and the influence of adult education.

The powerful combination of a need for pesticide safety and IPM education and the effectiveness of past efforts suggest the importance of fresh efforts in this area. The evidence implies the need to effectively utilize traditional extension services for the delivery of pesticide-related farmer health and safety information. Some important areas for intervention include expanding farmer first aid education, eliminating the risk of taking meals in cotton fields, improving sprayer maintanance, and promoting the safe use of protective clothing.

In Zimbabwe, much effort is currently devoted to promoting new strategies like FFS-based IPM techniques. While IPM allows for judicious pesticide use, what is lacking is adequate pesticide hazard information to inform the term “judicious.” In-depth economic study of risk-benefit tradeoffs is needed for the most toxic pesticides. A clear policy implication of these findings is that farmers would be healthier if less toxic pesticides are used in cotton production because they cause significant health problems for the farmers. However, a policy to phase out or reduce the use of the risky “purple” and “red” pesticides without identifying safer substitutes could be short sighted for Zimbabwe. It is also possible that safe pesticide handling may be as important or more important than pesticide toxicity.

Two areas are key to future pesticide policy in Zimbabwe’s smallholder cotton, 1) pesticide safety education and 2) toxic pesticide benefit-cost review. Indiscriminate use of pesticides is often a result of ignorance that can be addressed through education and training. Extension programs need to give a more prominent role to the diffusion of health information. Pesticide safety education should utilize a simple curriculum that more successfully engages illiterate rural farmers. These programs should deliberately target male farmers who often miss extension messages due to off-season migration for employment.

Future efforts to measure pesticide benefits and costs should cover the health costs of all individuals exposed to pesticides, including children and hired workers. Self-reported health conditions attributed to pesticide exposure can lead to problems of bias and endogeneity. Pesticide-related health symptoms can be measured more accurately by relying on independent experts to assess farmer health status. More complete estimates of illness costs would also incorporate the costs of pesticide-induced chronic illnesses and deaths. Longitudinal farmer health study designs could provide more and better insights about the causes of chronic health effects from pesticide use. So long as hazardous pesticides remain a major tool for agricultural pest management, farmers in Zimbabwe and elsewhere will need complete and reliable information on how to manage the inherent health hazards safely.

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Table 1: Descriptive statistics for Sanyati and Chipinge districts, Zimbabwe, 1998/99

Variable	----------Sanyati------------		---------Chipinge--------	
	Mean	**Standard Dev.**	**Mean**	**Standard Dev.**
Farmer characteristics				
Age (years)	46.40	14.20	42.70	12.58
Education (years)	6.54	3.72	6.54	3.75
Male farmers (0,1)	0.83	0.38	0.91	0.29
Formal employment (1,0)	0.46	0.50	0.43	0.50
Radio ownership (1,0)	0.68	0.47	0.73	0.45
Health-related and pesticide exposure variables				
Acute symptom cases	1.12	0.84	0.95	0.88
Acute symptom severity	0.60	1.00	1.01	1.42
Health cost (Z$)[3]	180.00	157.16	315.63	506.00
Purple pesticides (mg/kg/farm)[4]	416.00	2,983.00	1,219.00	6,569.00
Red pesticides (mg/kg/farm)	2,429.00	5,758.00	4,600.00	9,499.00
Amber pesticides (mg/kg/farm)	3,423.00	14,335.00	5,496.00	16,537.00
Eat in cotton fields (1,0)	0.10	0.30	0.28	0.45
Label illiteracy (1,0)	0.32	0.47	0.54	0.50
Sprayer leak (1,0)	0.39	0.49	0.34	0.48
Storage hazard (1,0)	0.36	0.48	0.21	0.41
Smoking duration (years)	2.14	5.11	2.78	7.03
Alcohol intake duration (years)	3.65	6.63	9.66	13.70
Farm management variables				
Cotton area (ha)	4.57	3.98	8.74	11.56
Cotton bales (bales)	8.12	7.63	19.30	16.82
Knapsack (1,0)	0.69	0.47	0.42	0.49
Ultra-Low Volume (1,0)	0.05	0.22	0.26	0.44
Prophylactic spray (1,0)	0.30	0.46	0.26	0.44
Institutional and human capital variables				
IPM Train (0,1)	0.48	0.50	-	-
Extension meetings	4.67	6.37	13.04	11.24
Items of protective clothing	3.76	1.54	1.76	1.77
First aid knowledge (0,1)	0.61	0.49	0.19	0.40
Access to borehole (1,0)	0.37	0.48	0.67	0.47
Distance to health center (km)	4.93	2.82	9.30	5.63

Source: Maumbe, 2001

[3] US$1.00 = Zim$38.00 at time of survey in 1998/99.
[4] Pesticide dosage/concentration is expressed as active ingredients that are measured in mg/kg. Farmer's exposure is measured as product of pesticide concentration and rate of pesticide application per farm.

Table 2: Pesticide-related health symptoms, 280 Zimbabwean smallholder cotton growers, 1998/99

PESTICIDE-RELATED SYMPTOMS	SANYATI (N=140)		CHIPINGE (N=140)	
	Percent	Number	Percent	Number
Acute symptoms				
Skin irritations	67.4	95	55.0	77
Sought medical treatment	2.8	4	7.9	11
Eye irritations	37.6	53	26.4	37
Sought medical treatment	2.1	3	7.9	11
Stomach poisoning	7.1	10	12.1	17
Sought medical treatment	2.8	4	5.0	7
Other systemic symptoms				
Nausea	1.4	2	5.7	8
Vomiting	1.4	2	0.0	0
Abdominal pains	9.2	13	2.9	4
Blurred vision	5.0	7	6.4	9
Dizziness	19.9	28	10.0	14
Nasal bleeding	1.4	2	0.7	1
Severe headache	3.5	5	0.0	0
Coughing	1.4	2	1.4	2
Sneezing	9.2	13	0.0	0
Diarrhea	0.0	0	1.4	2
Multiple symptoms	7.8	11	23.6	33
None of the above	39.7	56	47.9	67

Source: Maumbe, 2001.

Table 3: Pesticide use by toxicity class, 280 Zimbabwe smallholder cotton farmers, 1998/99

PESTICIDE TOXICITY COLOR CODES	PESTICIDE HAZARD CLASS	SANYATI DISTRICT	CHIPINGE DISTRICT
		Percent	Percent
I. Purple	Very Dangerous	5.1	5.1
II. Red	Dangerous	54.3	19.9
III. Amber	Poisonous	40.6	75.0
IV. Green	Harmful if swallowed	0.0	0.0

Table 4: Cost of illness model results, Sanyati and Chipinge Districts, Zimbabwe, 1998/99.

Dependent variable: Natural logarithm of farmer health costs (Z$)

Independent variables	**Sanyati District**		**Chipinge District**	
	coefficient	**t-statistic**	**coefficient**	**t-statistic**
Farmer characteristics				
Farmer age	0.0060	0.04	0.1800	0.83
Male farmer	-0.1700	-1.51	0.0049	0.02
Formal education	0.0330	1.34	0.0310	0.66
Health-related variables				
Acute symptoms[1]	***0.1600	4.54	***0.2900	4.35
Symptom severity[2]	***0.0890	2.63	**0.1200	2.01
Alcohol consumption	0.0067	0.30	-0.0210	-0.73
Smoking	*0.0470	1.92	-0.0032	-0.09
Institutional variables				
Borehole access	-0.0074	-0.09	-0.0820	-0.63
Health center distance	-0.0088	-0.63	0.0340	0.42
First aid knowledge	-0.0830	-1.04	-0.0730	-0.46
Adjusted R^2	31		35	
N	137		131	
p-value	0.000		0.000	

***=significant at 1% level, **=significant at 5% level, * =significant at 10% level

Note:

1. Three types of pesticide-induced acute symptoms were assessed in detail, eye irritations, skin irritations and stomach(gastro-intestinal effects) irritations.
2. Symptom severity was assessed on a scale of 1 to 3 with 1= mild, 2=severe and 3=very severe. The severity variable is a product of positive acute symptom and its severity aggregated across all the three acute symptoms under investigation. Its value ranges from 0 to 9.

Source: Maumbe, 2001

Table 5: Poisson model results for self-reported total acute symptom incidences[5], 1998/99

	Sanyati District		Chipinge District	
Independent variables	**coefficient**	**z-value**	**coefficient**	**z-value**
Farmer characteristics				
Farmer's age	***-0.0790	11.01	*0.0150	1.71
Formal education	0.0210	0.95	***0.1000	3.69
Male farmer	***1.4100	4.37	**0.8900	2.32
Farm management variables				
Total area cultivated	***0.0630	3.40	**0.0120	2.08
Formal employment	0.0530	0.30	***-0.6800	-3.72
Knapsack	0.1900	1.19	***-0.8800	-4.27
Health-related variables				
Alcohol consumption	*0.0280	1.79	0.0130	1.30
Smoking	-0.0060	-0.34	0.0140	1.01
Exposure variables				
Purple pesticide dosage	***0.3100	2.77	0.0380	0.57
Red pesticide dosage	*0.1300	1.86	***0.0970	2.86
Amber pesticide dosage	-0.0210	-0.58	**-0.0620	-2.26
Sprayer leak	0.1700	1.09	***0.8200	4.91
Meals in cotton fields	**0.6000	2.29	0.2900	1.52
Label illiteracy	*0.2600	1.75	0.4200	0.03
Institutional and human capital variables				
IPM graduate	-0.2800	-1.35	-	-
Extension meetings	***0.0930	6.44	***0.0170	2.06
First aid knowledge	***-0.5100	-3.46	**-0.5000	-2.14
Protective clothing	***-0.1500	-3.56	*-0.1000	-1.76
Borehole access	***0.6900	4.23	0.2000	1.13
Credit use	-0.3000	-1.51	***-0.6200	-2.98
Radio ownership	***-1.2100	-7.66	0.1600	0.78
Pest management perception variable				
Doubts need to calendar spray	***-1.1500	-4.75	*-0.3100	-1.71
N	133		119	
Log likelihood chi-square	495.54		165.81	
χ^2–p value	0.0000		0.0000	

***=significant at 1% level, **=significant at 5% level, * =significant at 10% level
Source: Maumbe, 2001.

[5] Acute symptom incidences refer to short-term illness episodes experienced by the farmers and these include both the dermal (eye and skin irritation) and oral (ingestion) symptoms. Therefore, the total incidence model aggregates skin, eye and stomach (gastro-intestinal) poisoning episodes incurred by the farmer during and or soon after spraying pesticides.

Table 6: Poisson protective clothing adoption determinants for smallholder cotton growers, Zimbabwe, 1998/99

Dependent variable: Count of protective clothing ownership

	Sanyati District		Chipinge District	
Independent Variables	**Coefficient Estimate**	**z-value**	**Coefficient Estimate**	**z-value**
Farmer characteristics				
Farmer's age	***-0.0140	-2.97	0.0120	1.32
Formal education	-0.1300	-1.06	***0.5700	2.48
Male farmer	0.0790	0.56	0.2200	0.64
Radio ownership	-0.1700	-1.43	-0.2500	-1.36
Farm management variables				
Total area cultivated	0.0046	0.34	-0.0110	-1.29
Formal employment	0.0840	0.73	**-0.5200	-2.93
Certified master farmer	-0.0440	-0.36	-0.1200	-0.63
Knapsack	**0.2300	2.15	**-0.4100	-2.06
Prophylactic spray	0.1800	1.50	0.2600	1.38
Health-related variables				
Predicted skin incidences	***-0.3000	-3.91	***-0.4300	-5.80
Predicted eye incidences	-0.0880	-0.99	-0.0850	-0.49
Alcohol consumption	0.0860	0.66	*-0.2800	-1.63
Smoking	-0.0410	-0.29	0.0790	0.35
Exposure variables				
Purple pesticide class	-0.3100	-0.62	-0.3900	-1.20
Red pesticide class	0.2400	0.58	***0.6000	3.23
Amber pesticide class	0.0082	-0.86	-0.2100	-1.50
Label illiteracy	-0.0410	-0.36	***-0.8000	-4.76
Institutional and human capital variables				
First aid knowledge	0.0610	0.60	0.2500	-1.37
IPM awareness	*0.1200	1.72	-	-
Extension meetings	*0.0190	1.88	***0.0460	5.58
Distance to health center	0.0085	0.44	-0.0036	-0.25
N	133		117	
Log Likelihood χ^2	44.69		101.43	
χ^2 –p value	0.0019		0.0000	

***=significance at 1% level, **=significance at 5% level, * =significance at 10% level

Source: Maumbe, 2001.

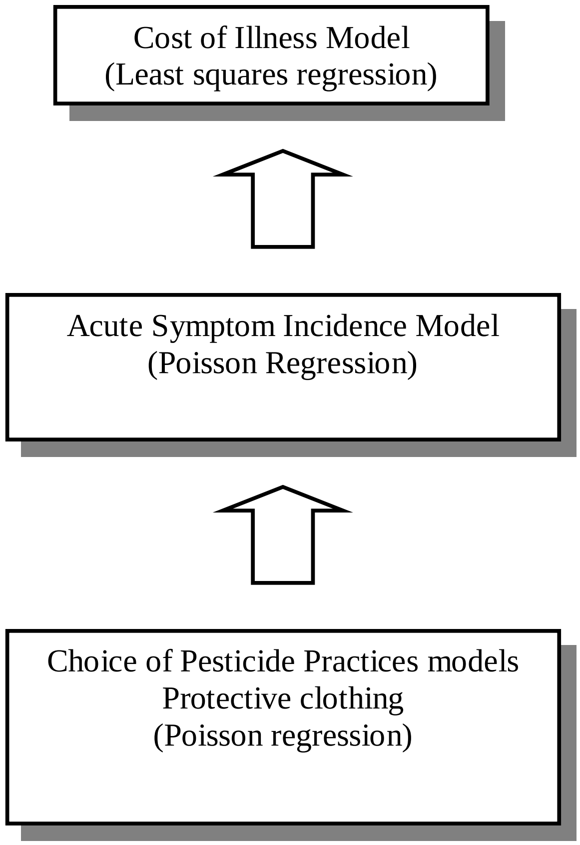

Figure 1: Econometric modeling sequence to identify determinants of pesticide-related health costs.