Pesticide Use in the Rice Bowl of Kerala: Health Costs and Policy Options

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Abstract

This study examines pesticide use in Kuttanad, India, an economically sensitive area often referred to as the rice bowl of Kerala. Using primary data collected from pesticide applicators and farm labor, the study assesses short-term health costs associated with pesticide exposure. The study finds that the toxicity level and dose of pesticides can exert a significant effect on the health of pesticide applicators. The average expected health costs from pesticide exposure are Rs. 38 (US $ 0.86) per day or 24% approximately a quarter of the average daily earnings of the applicator.

The study finds that health costs can be mitigated considerably by reducing the dose of pesticides used. For examples, a 25% reduction in either the does of the most toxic chemical used, or in all pesticide doses, results in a 16% and 24% reduction in health costs respectively. A 24% reduction in costs can be realized if all pesticide doses are reduced by 25%. Dose reduction is a desirable and feasible strategy that can be achieved either by restricting the quantity of pesticide used or by diluting the amount sprayed with the recommended levels of water. Less than 2% of the applicators understood the toxicity levels of the pesticides they used. Thus, there is ample scope for reducing pesticide exposure through training and agricultural extension services.

Key Words: Pesticide Exposure, Dose-response functions, cost-of-illness, India

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1. Introduction

According to World Health Organization estimates, pesticides cause 30,00,000 cases of poisoning and 2,20,000 deaths annually across the globe, the majority of which are reported from developing countries. These numbers, even more alarmingly, show a rising trend (WHO, 1990; DTE, 2001; Rosenstock, et al., 1991; Pimental, 1992; Kishi, et al., 1995; WRI, 1998). While indiscriminate use and unscientific handling of toxic chemicals are very common, the extent, severity and frequency of associated health problems are often unknown.

Pesticide-related health damages are difficult to identify, particularly in developing countries, because of inherent problems of poverty, inadequate health care facilities, poor training support to health-care personnel, and unsatisfactory access to the health care system. Furthermore, the major victims are the most vulnerable sections of the population. The farm workers, small and marginal farmers and women, who are the most often exposed owing to occupational factors, neglect the health hazards of pesticide exposure due to either lack of awareness and/or due to financial reasons. This may perhaps explain the lack of research on the impacts of pesticide exposure. There have of course been attempts on a limited scale in some developing countries to value the health damage due to pesticide exposure (Jeyaretnam, 1990; Ngowi, 2002; Wilson, 2002). Such studies, however, have not been reported in India thus far. This study was undertaken to fill this existing gap in knowledge.

Both media and scientific attention to pesticide use and its effects gained momentum in India only very recently. Moreover, a review of studies on this topic suggests that it is heavily loaded with research from the physical sciences with little contribution from economics. Many scientists report the presence of insecticide residues in soil, water bodies, air, food materials and the bodies of living beings (Mencher, 1991; Brahmaprakash and Sethunathan, 1987; Gangamma and Satyanarayana, 1991) but few evaluate impacts in economic terms. This study looks at the pesticide use pattern in an ecologically-sensitive rice ecosystem of Kerala, India, and assesses the value of health damage among farm workers. The main objectives are to understand a) the pattern of pesticide use and the precautions taken in handling pesticides in Kerala; b) the acute health effects of pesticide exposure among the different types of agricultural labor; and c) the monetary health costs associated with exposure.

The effect of pesticide exposure may be of three types, namely, short-term high-dose exposure (to applicators, workers in production centers, stockists at sales outlets, and in attempted suicides); long-term high-dose exposure (workers in production centers and applicators); and long-term low-dose exposure (all population groups). This naturally has both morbidity and mortality effects. This study focuses on short-term exposure to applicators.

While pesticide exposure has many long-term chronic effects, assessing these impacts is beyond the scope of this study. The morbidity effects of pesticide exposure are discussed in detail in Forget, 1991; Rola and Pingali, 1993; Antle and Pingali, 1994; Crissman, et al., 1998; Antle, et al., 1998; Cole, et al., 1998; Wilson, 2002; and Dasgupta, 2005. However, Dasgupta (2005) reports very weak association between the farmers' self-reported symptoms of pesticide exposure and actual poisoning (blood test results). Hence studies, which depend on self-reported symptoms, may reflect a lower estimate than that which might be said to prevail in actual fact.

The paper is presented in six sections. Section 2 provides an overview of pesticide use in Indian agriculture while Section 3 gives an account of the data, study-site and sample characteristics. Section 4 describes the analytical approach and explains the statistical models used in the work. Section 5 describes the findings on the probability of getting sick and the expenses when it comes to health damages. Section 6 discusses policy measures.

2. Pesticide Use in India

Pesticide use in India dates back to the year 1948 when DDT and BHC were imported for malaria and locust control. Currently, India is the No. 1 manufacturer of basic pesticides in Asia and ranks 12th globally. Among the predominant classes of pesticides used in India are insecticides, which account for 75 per cent of total consumption, followed by fungicides (at 12 per cent) and herbicides (at 10 per cent). Furthermore, 54 percent of the total quantity of pesticides used in the country is used in cotton, with 17 per cent in rice and 13 per cent in vegetables and fruits.

The pesticide residues in food in India, especially vegetables, are the highest in the world. This is mainly due to the unregulated use of pesticides. Persistent pesticides like BHC and DDT remain in the ecosystem for longer periods and pose great danger to the soil/water bodies and the dependent life-systems. Chemical pesticide residues have often been detected in food grains, vegetables, fruits, oils, cattle feed and fodder in most parts of the country. About 72 per cent of food samples in India have shown the presence of pesticide residues within tolerance levels while in 28 per cent samples they were above the tolerance level as compared to 1.25 per cent globally. On a comparative basis, very high levels of organic chlorine compounds have been reported in human blood, fat and milk samples in India (Bhatnagar, 2001). As a consequence, India accounts for one-third of the total pesticide poisoning cases in the world (Puri, 1998).

However, pesticide consumption in India has recorded a decline in recent years. The pattern is the same for Kerala too. But the intensity of use (quantity per hectare) in the state has increased (Appendix F: Figs.1, 2, 3 and 4). In contrast to the national pattern, however, the fungicide use in Kerala is much higher (at 57%) when compared with the use of insecticides. This is generally attributed to the higher proportion of plantation crops in the state.

The Department of Agriculture, Government of Kerala, is the implementing agency for the Insecticides Control Order. The Agricultural Officers (one officer each for every panchayat) are designated as the insecticide inspectors. In addition, there are separate quality control laboratories in various parts of the state. However, the quality control arrangements by the department appear to fall far short of desired standards. Though sub-standard pesticide samples are often reported, until recently, little action was taken on such reports. The only action taken was to stop the sale of the particular substandard batch of pesticide—however, by the time such decisions were implemented, most of the pesticides were already sold. Similarly, the statistics provided by the Health Services Department of the State show that there are no cases of health hazard due to occupational exposure to pesticides, which is quite unrealistic. What all this goes to show are serious inadequacies in data at all levels.

There have been multiple episodes of pesticide poisoning reported in Kerala. The Kerala State became the focus of pesticide literature following the death of more than 100 people in the year 1958 after consuming wheat flour contaminated with pesticides during transportation. The state-owned Plantation Corporation of Kerala began the aerial spraying of Endrin (later Endosulphan) way back in the 1970s in their cashew plantations, which has been associated with the outbreak, among local people, of severe health problems such as cancer. In each household, at least one person has been found to work in cashew plantations and 156 cases of disorders from 123 households were noted during the period 1990–2001 (Rajendran, 2003). Pesticide residues are detected in fruits and vegetables, bottled drinking water, soft drinks, milk and other food items. Furthermore, cases of cancer observed in a village near the cardamom plantations in the State have been attributed to the high pesticide use.

A study undertaken by the Thiruvananthapuram Medical College has reported very frequent cases of cancer of the lip, stomach, skin and brain, lymphoma, leukemia and multiple myloma from the Kuttanad rice area of Kerala, linking the same to high pesticide use in the area (Dinham, 1993). A recent survey conducted by a volunteer group makes a similar observation regarding the rising trend in cancer patients in Kuttanad, identifying pollution as one of the reasons. Reports on the reduction in the fish population and massive deaths due to ulceration in fish in Kuttanad also appear very frequently in the local media.

Rakhesh, (1999) studying the externalities associated with pesticides, has found that pesticide poisoning leads to both explicit and implicit costs for the applicator/ farmer. In his study, majority of farmers (60%) reported that they were suffered from health problems caused by pesticides. In another study, Krishna (2001) has found skin allergy and headaches to be, among the health hazards induced by pesticides, skin allergy and headaches were found to be the most prominent pesticide-induced health hazards. Krishna reports that most farmers were aware of these negative impacts and were willing to incur an additional cost of Rs 138 per hectare of rice farm for an alternate eco-friendly agricultural practices.

3. Study Area and Data

Kuttanad is a low-lying area near the coast of Kerala, India, with a total population of 1.4 million (Census, 2001). It is called the rice bowl of Kerala. Rice cultivation in Kuttanad is however of a special type, as the land is on average three meters below the Mean Sea Level (MSL). Paddy is virtually the only crop grown and the poor drainage conditions make most of the land in the area unsuitable for other crops. Coconut is grown on the bunds and on the higher areas. The main rice crop of the area is the punja (summer crop). In some areas, a second crop (viruppu) is possible. The punja season is generally the period from October/November to March/April, i.e., after the cessation of the North-East monsoon and before the ingression of saline water during the summer months. This study was conducted during the punja crop of 2004-05.

The paddy fields in Kuttanad are classified into three types as Karapadom, Kayal and Kari lands based on physiographic and soil characteristics. Rice fields are usually demarcated as padasekharams. A contiguous stretch of wetlands bounded by waterways or other natural features is called a padasekharam, which is a homogeneous physical entity.

For the purposes of this study we collected pesticide-related information from a sample of pesticide applicators and agricultural laborers. To select our sample, two Community Development Blocks were randomly selected from each of the three districts which form the Kuttanad area. From each block two panchayats were identified. From each selected panchayat, three padasekharams were chosen on a random basis and these padasekharams formed the study area.

As noted earlier, the respondents for this study belong to two groups: Pesticide Applicators and Agricultural Laborers. Pesticide applicators are those who generally undertake the pesticide-spraying job during the peak season of spraying. They are considered skilled labor for this type of work. During the off-season period when spraying operations are limited, they engage in other types of agricultural and non-agricultural work. We collected data from 280 applicators. The agricultural laborers are those who engage in farm operations such as ploughing, fertilizer application, land preparation, etc., but do not undertake pesticide spraying. They also opt for non-agricultural work during the off-season. We surveyed a total of 101 agricultural laborers for this study.

Data collection was through a structured pre-tested questionnaire, by the personal interview method, and through a farm diary maintained by the respondents, which was closely monitored by the research team (Appendix B, C, D& E). The data included both qualitative and quantitative attributes. Direct observations were also made wherever possible.

The data set for the study consisted of three components:

i) Pesticide applicators during pesticide application work (n= 280): Each applicator was contacted four times during the spraying season, which lasted for five weeks. During these visits data on the spraying details and the health status after the spray operations (within a period of 24 hours) were gathered. Hence, on average, for each respondent four dose-response observations data are available and the total data set includes 1135 observations. However, some of the respondents were interviewed 5 times while others could be met only two times due to their work schedules.

ii)) Pesticide applicators when they undertake work other than pesticide application during the off-season (n= 212): The applicators undertake wage labor in farms or other sectors when spraying operations are not available. The same applicator was contacted again during the off-season (when it comes to spraying) and data was gathered. The data set here includes observations from 212 respondents.

iii) Agricultural laborers: This group comprises the farm workers who do not undertake pesticide applications (n=101). The data on them includes responses related to both types of work—agricultural and non- agricultural work. Here the data set includes responses from 101 laborers.

Data collectors were hired locally with the help of local Agricultural Officers. Their familiarity with local conditions and access added much to the quality of the data collected. The data collectors were either graduates in science or diploma holders in agriculture. Generally, the visits for the dose-response part of the data were undertaken during the morning hours before the workers left for work. During these interviews details were gathered on the previous day's spraying operations and its health response during these visits. Spraying operations were also directly observed on a random basis. Help from family members was also sought when estimating the cost incurred on account of sickness.

Table 1 furnishes the socio-economic profile of the respondents. The average age of applicators in the sample was 45 years, the minimum being 23 and the maximum 70. The mean age was slightly higher in the agricultural labor group. It is possible that the more risky jobs are taken up by younger people. Though some of the respondents in the applicator group have studied up to university level, most of them had studied only up to the 7th standard. On the other hand, the education level of agricultural laborers was only up to the 4th standard.

Pesticide application, as a general practice, is of shorter duration than other wage labor in the agricultural and non-agricultural sectors. The average work period is 2.18 a day when it comes to pesticide application work. However, the same group of respondents spent 6.3 hours at other agricultural work and 3.84 hours on average on non-agricultural work.

Pesticide applicators are paid more than twice the wages in the agricultural sector. While the payment for pesticide applications is Rs 73 per hour, wages for other agricultural work is approximately Rs.30 per hour. In the non-agricultural sector, however, payments are slightly higher — but not as high as in pesticide application work. The non-agricultural work taken up by the applicator group is generally of a skilled nature (electrical work, machinery handling, driving, etc.). The non-agricultural wages were on average Rs 52 per hour. Interestingly enough, the average earnings per day for pesticide application is Rs 159, which is lower than the daily earnings of agriculture workers and applicators via other work. When applicators opt for agricultural work, their earnings go up by 20% and it is 24 % higher in the case of non-agricultural work. Nonetheless, further exploratory analysis is required before a conclusion can be arrived at as to whether the applicators were properly compensated for the risk they face.

Rice cultivation in Kuttanad is of an intensive nature compared to many other parts of the state. Nearly 90% of the farmers sow high-yielding varieties, necessitating the use of high levels of chemical inputs. Moreover, the area is prone to pests such as Brown Plant Hopper. The Kerala Agricultural University restricts the use of certain chemicals for rice in the area (methyl parathion and BHC). Interestingly, the most commonly used chemicals in the region were methyl parathion, followed by monocrotophos. Some of the chemicals used however are not among the recommended chemicals.

Table 2 gives the list of chemicals used in the area and its use level. Among the 19 used twelver insecticides, four fungicides and three weedicides. The majority are systemic in action while twelve belong to the organic phosphorous group of chemicals. Compared to organo-chlorines (which are more persistent), organo- phosphates and carbamates are less persistent but more toxic. Organo- phosphorous pesticides are found to be responsible for death in more than 70% of the cases of pesticide-poisoning in India .

The dose of the spray fluid used in the study area was found to be much higher than the recommended level in all cases. This conclusion was arrived at through a comparison with the recommended dose suggested by the Kerala Agricultural University in the case of those chemicals where a recommendation exists. In the case of the other chemicals, the manufacturer's prescription was used as a guide. More often than not, the quantity of the formulation was well in excess of the recommendation while the water used was below the recommended level.

Our study shows that 40% of the spraying is undertaken to protect the crop against the pest Brown Plant Hopper, 17% against the rice bug, and 16% to control against leaf folder. Spraying is done with a knapsack sprayer that is either owned by the farmer or hired from other sources. Most owners (88%) buy the chemical to be sprayed and entrust the applicator with the spraying. Generally, spraying operations were not supervised. The mixing of the chemical with water is generally done in a separate container using water from local water bodies. Sometimes the water and the chemical are poured together into the sprayer and shaken (22%), which is against scientific good practice.

Extremely toxic chemicals, marked red, are seen in use in 21% of spraying events in the study area. The frequency of use of highly toxic chemicals (marked yellow) is 51.25%, the use of moderately toxic chemicals (marked blue) is 22.55% while the rest are comparatively safer chemicals. More often than not, applicators perceive the toxicity levels to be lower than the actual toxicity levels. Only 33% of the applicators read the label on the bottle while only 2.5% took steps to follow the instructions. A mere 1.5 % understands the toxicity level associated with the color code.

Many potential health damages and acute symptoms of exposure to different chemical groups of pesticides are reported in the epidemiological literature. Following these findings and on the basis of the major groups of pesticides used, 17 major symptoms were identified prior to undertaking our survey. Based on responses from the survey, in 71% of spray events, the pesticide applicators reported some form of health impact relative to 45% of the times when they engaged in other work. In the case of agricultural laborers, it was 32% (Table 3).

Skin problems were reported as the most common symptom and itching was more frequent than hives. Eye-irritation and vision problems were also very common. However, these were regarded as minor ailments that were often managed by the workers themselves. Home remedies or traditional ayurvedic treatment were resorted to in these cases. Allopathic treatment was resorted to in only the more serious cases. Though the frequency of symptoms like nausea, giddiness, breathing problems, dehydration, vomiting, cramps, convulsions, diarrhea, etc., were comparatively less, they are more life-threatening and hence formal medical advice was sought more often in such instances.

The severe symptoms are breathing problems, dehydration, vomiting, cramps and diarrhea which often manifest themselves soon after spraying and result in hospitalization. In a majority of cases the person is taken directly from the farm to the hospital. In such cases people preferred to go to private hospitals owing to better care and facilities. This is also reflected in macro-level data where we find that the public health care system reports no cases of occupational health damage due to pesticide exposure.

In our study, we found 76 cases of hospitalization among the 894 cases of sickness related to pesticide exposure. The expenditure on hospitals ranged from Rs.450 to Rs. 3780 with a mean of Rs.1536. Where there is hospitalization, the days spent in the hospital range from one day to one week. In the other two groups there were no cases of hospitalization consequent to work hours.[1]

The majority of the respondents were aware of the potential health hazard due to exposure and the need for personal protective gadgets. Jeyaratnam, et al., (1987) and Sivayoganathan, et al., (1995) have also attested to this situation in the case of Sri Lanka. However, none of the applicators used the suggested protective gadgets, which include a face-mask with replaceable filters, goggles, head-cover, rubber gloves, full-sleeved shirts and full pants, and boots. The cost factor, general lethargy, and the discomfort associated with the use of protective devices under hot and humid climatic conditions and in water-logged paddy areas were reported as the reasons for non-adoption. Moreover, there exists no mechanism to ensure their use.[2]

Nonetheless, some form of protective covering of body parts was adopted by 71% of the respondents while spraying. In 21% of the cases, it was mainly full- sleeved shirts. However, many rolled up their sleeves while spraying/mixing. Thirty one percent of applicators tied a piece of cloth around the nose. A mere 1% used some form of eye protection (e.g., ordinary spectacles, which are in use even otherwise). These unscientific methods for avertive action often fail to achieve the desired objectives.

4. Methods

In order to estimate the economic impact of pesticides on human health, two types of information are required. First, the physical health impacts of the exposure need to be identified; second, the monetary health cost associated with this exposure need to be assessed (Freeman, 2003). In this study, we estimate a dose-response model for quantifying the physical impact and then we estimate the cost-of-illness.

4.1. Dose-Response Model

A dose–response function presents a statistical relationship between exposure to pollutants and health risks. Dose-response functions frequently form the physical basis of economic models used to estimate the health costs of pollution. They involve the estimation of a relationship between illness and the ambient pollution levels while controlling for other variables (socio-economic and behavioral) that affect health status (Cropper and Freeman, 1991).

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1 *The private health care system in Kerala is often reported to be very costly. A recent study by Kerala Shastra Sahithya Parishad, a noted NGO in the state, estimates the annual per capita treatment cost in the state as Rs.1722 and the cost per event of treatment as Rs.830.70. This amounts to 1.9 % of family expenditure. On average 64.4 % of the people depend on private medical systems .The average expenditure per hospitalization is Rs. 9680. In the case of the private system it is as high as Rs. 10445 (A ravindan, 2006).*

2 *In the plantation sector, employers are provided these gadgets as part of labor welfare measures.*

In this study, following studies by other scholars (Dasgupta, 2004; Huang, et al., 2001; Jalan, et al., 2003; Dasgupta, et al., 2005) the dose-response function, is estimated where the dependent variable is a binary variable. This function gives the probability of getting sick after an event of pesticide spray after controlling for other factors. The reason the dose-response function is estimated as a probability function is because the data does not permit the estimation of a continuous sickness function. There were hardly any sick days when work stopped as a result of pesticide exposure. Thus, it is not possible to estimate a regular sickness function with sick days as a continuous dependent variable.

The use of probability models is conceptually preferable to conventional linear regression models when the dependent variable is dichotomous. The probability models provide parameter estimates, which are asymptotically consistent and efficient. In this section, a Probit model is used to study the determinants of the probability of getting sick. The general model is a binary choice model involving estimation of the probability of falling sick (y) as a function of a vector of explanatory variables (x). It is assumed that there is an underlying response variable y^*_i defined by the regression relationship (Gujarati, 2004).

$$y_i^* = \beta' x_i + u_i \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

In practice, y^*_i is unobservable and , what is observed is a dummy variable y defined by

$$y = 1 \text{ if } y^*_i > 0 \quad (\text{SICK} = \text{YES})$$
$$= 0 \text{ otherwise } (\text{NOT SICK} = \text{NO}) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

From the above relations, we get

$$Prob\ (y_i = SICK) = Prob\ (u_i > -\beta' x_i) = 1 - F(-\beta' x_i) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where F is the cumulative distribution function. Hence, we obtain the following likelihood function

$$L = \prod_{y=0} F(-\beta' \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Taking the logarithm of L and maximizing with respect to β, which gives us the maximum likelihood estimator of the slope coefficients from which we can estimate the impact of different doses of pesticides on the probability of falling sick. The explanatory variables used in the Probit model and the expected signs are presented in Table 4 and described below. The dataset for estimating the dose-response variable includes 1448 observations from applicators (both during days when they were exposed to pesticides and when they did other work) as well as other agricultural laborers when they were doing field work.

Y (1= sick or 0=not sick): The health effects of pesticide exposure are manifested as specific symptoms or a combination of a few symptoms. Building on scientific information as well as a preliminary pilot study, 17 types of symptoms were first identified. Based on whether or not pesticide-related symptoms were reported, a sickness dummy variable was created. This is the dependent variable in the dose-response function.

Body Mass Index : The Body Mass Index (BMI) gives a measure of the general health status of the individual. A BMI value between 18.5 and 25 is reported to be the desirable value and any value below or above is undesirable. The lower values represent the risks due to malnutrition while the higher values reflect the danger of obesity. Malnutrition is a possibility with our sample and hence the expected sign of this variable is negative. (see Appendix E for further details)

Pesticide Dose: These variables captures the dilution of spray fluid and the toxicity of the chemical used. WHO has prescribed a color code for chemical pesticides according to the toxicity level. This is based on their LD_{50} value. The Lethal Dose (LD) is the quantity required to kill 50% of the target population. The lower the value, the more toxic the chemical is. Extremely toxic chemicals are marked red (LD_{50} less than 50), highly toxic chemicals as yellow (LD_{50} value 50-500), the moderately toxic as Blue (with LD_{50} 500-5000) and the slightly toxic as Green (LD_{50} value greater than 5000). In our study, the dose variable captures the effect of the dilution of the spray fluid. It is a function of the quantity of the chemical used, the concentration of the formulation and the quantity of water used. Based on data on spray dilution, pesticide used and concentration, we created four variables that represent the pesticide dose: DRed (Dose of RED category), DYellow (Dose of YELLOW category), DBlue (Dose of BLUE category) and DGreen (Dose of GREEN category). We expected a positive sign for all the four variables. These variables took the value zero for workers who were agricultural laborers or for applicators on non-applying days.

Duration of Exposure: This variable represents the total time taken for preparing the spray fluid and actual application by the pesticide applicator. For non-application days and for agricultural workers, this is the duration they engage in work. This variable is expected to have have a positive sign.

Temperature in degree Celsius: In tropical countries the temperature gradient during the spray has an influence both on the general health status of the worker as well as the decomposition of the chemical. We collected the maximum day temperature on the day of the spraying from the records maintained by the Rice Research Station, Alappuzha, which is the nearest station recording meteorological observation for the Kuttanad area. We expected a positive sign for this variable.

Personal Habits: The primary data showed smoking and alcohol consumption as the key personal habits that pose a health danger to farm workers. These two variables were included as two separate dummy variables and we expected a positive health risk to be associated with smoking and alcohol consumption.

Education: Education was expected to have a negative impact. The more educated people were expected to be at a lower risk owing to better awareness. The respondents were grouped into three groups based on the education level— from 1 year of schooling upto 4 years, from 5 years up to the 7 years and above 7 years . Two dummy variables were used to estimate the effect of education on the probability of sickness. The first group (upto 4 years) was the default group and the next two, i.e. from 5 years to 7 years and above 7 years were taken as two dummy variables.

In the initial part of the analyses, dummy variables were also included to control for the frequency of visits made for data collection. But these did not have any significant influence and hence were dropped in the final regressions shown.

The dose-response function allows us to estimate predicted individual probabilities of sickness. The expected mean probability of sickness was then estimated for each group of pesticide applicators on applying days, pesticide applicators while doing other type of work and agricultural laborers.

Undertaking sensitivity analyses, the probabilities of sickness under four policy contexts for the first group were also estimated: a) the probability of sickness if there is a decline in dose of all chemicals by 10% from the current level; b) the probability of sickness if there is a decline in dose of all chemicals by 25% from the current level; c) the probability of sickness if there is a decline in dose of the most toxic chemical (Red) by 25% from the current level; d) the probability of sickness if the most toxic chemicals (Red) are fully replaced by safe chemicals (Green).

4.2. The Cost of Illness

The next step of the analysis was to identify the monetary costs associated with sickness that resulted from pesticide exposure. In general, estimation of economic value of health damages is undertaken using three major approaches (Wilson, 1998): Avertive / defensive expenditure method, cost-of-illness method and contingent valuation method.

The cost-of-illness method (COI) is perhaps the most widely used approach and involves estimating the medical expenditure associated with illness, lost earnings due to lost work days or, value of productivity losses, the value of leisure hours lost, travel costs and special dietary expenses associated with medical treatment. Thus, the cost-of-illness estimates provide an account of the money spent in all direct and indirect aspects of illness, which includes the direct private costs (medical expenses) and indirect costs (loss of work days due to poor health, time spent on seeking medical help and losses due to poor efficiency). However, a wide variation can be observed in the literature in terms of what is considered under costs in COI studies. For example, Harrington and Portney (1987) takes only medical costs and wage loss into account, whereas Hodgson and Meiners (1982) includes transportation, special dietary costs, certain household expenses and certain property losses. In a more recent study, Maumbe and Swinton, (2003) exclude the travel and leisure time value as well as the cost of traditional and home remedies.

This study followed the method adopted by Wilson (1998). The cost- of- illness estimates thus include the doctor's fee, cost of medicines, laboratory expenses, transportation expenses (for the applicator and companion), hospital fees, dietary expenses, and earnings from lost work days (wages multiplied by time lost on account of sickness and time taken to travel to seek medical help).

Cost-of-illness estimates are considered a lower bound of the actual costs incurred as the estimate does not include the social costs incurred (Drummond, 1992; Jefferson, et al., 1996; Wilson, 2000). Apart from this, the estimate excludes the value of leisure time, disutility due to illness, losses due to poor work efficiency and productivity losses due to poor supervision or work in own farm.

Estimation of cost-of-illness in developing countries can pose several challenges. Poor countries, seeking medical help is rare among the low-income groups, unless the symptoms are very severe. If the symptoms are not acute, they are often neglected or home remedies are adopted, for example, bathing in water boiled with neem or tulsi leaves. In this study, it was found that it was easy to gather data when there was hospitalization or when the respondents sought formal medical help. However, when the symptoms were not considered very serious, formal medical advice was not sought and the respondents depended on self-medication or 'over-the-counter' medicines that are available without formal medical prescription. They also, adopted local practices (drinking tender coconut water), or consulted local ayurvedic practitioners (vaidyas). In such cases, the market value of the drugs/nutrition supplement and the opportunity cost of labor were imputed . In many cases, it was possible to obtain a clearer account of the expenses by talking to women folk in the house.

In this study, because of the high variability in the cost-of-illness, obtaining a simple average estimate of the cost-of-illness (as is often done in similar studies) is not justified. Hence, based on the medical advice, the health damages for each individual were categorized as as mild, moderate and severe. The average cost of illness (C) for each category is estimated as

$$C_j = \left[\frac{\sum_{i=1}^{N} (M.}{} \right] \qquad \text{.................. (5)}$$

Where,

C_j is the average cost-of-illness in the j th group, with j = 1, 2, 3 reflecting mild, moderate and severe symptoms

ME ij is medical expenditure incurred by the i th individual in the in the jth group

Wij is the wage rate of i th individual in the j th group and

Tij is the work-time losttime unable to work of by the i th individual in the j th group

and

Nj is total number of times the respondents reported sick in j th group.

The overall cost of illness ore welfare loss (Wj) due to sickness for individuals in each group is given by group is:

$$W_j = C_j \left[\frac{\sum_{i=1}^{N_j} \hat{F}}{} \right] \qquad \text{.................(6)}$$

. . . .

Nj

where,
Wj is the welfare loss in j th group
Cj is the average health cost in the j th group
P is the estimated probability of Y=1 in jth group
Nj is total number of times the respondents reported sick

Finally, we estimated the welfare loss due to pesticide exposure as the difference between the welfare loss of pesticide applicators during application days and that of the applicators during non-application days. We found that the estimated health cost for the two groups, applicators on non-applying days and agricultural laborers, to be the same.

Further the analysis is extended to assess the welfare gain through four management options as explained earlier.

5. Results

5.1. Dose response Function

The summary statistics of the variables used in the dose-response function and the results of the analysis are furnished in Tables 5 and 6. The dose-response model, which was estimated to assess the influence of the independent variables on the probability of sickness confirmed most of the assumptions and the signs of the significant coefficients were as expected. The dose of red, yellow and blue category chemicals, smoking, Body Mass Index and education levels recorded a significant influence on the dependent variable.

The dose of the toxic chemicals (red, yellow and blue), which captures the dilution of spray fluid and the concentration of formulation, exerts a strong positive effect on the health risk. We have observed that a majority of the sprayings (70 %) used red and yellow category of the pesticides and these have a significant effect on the probability of sickness. The safer dose (green) has an insignificant effect.

Smokers are more likely to fall ill after spraying compared to non-smokers and smoking appears to be more harmful than alcohol consumption. Alcohol consumption, which was expected to have a positive effect on health damage, shows a negative sign. However this coefficient is not significant.

The more educated experience fewer chances of falling sick after spraying, apparently due to better care in handling the chemical. However, this is not reflected in the adoption of scientific protection gadgets. None of the respondents used the recommended protective gears.

Lower values of the Body Mass Index reflect the health risks due to malnutrition whereas the higher values reflect obesity problems. In our sample, the chances of the former are more likely than that of the latter and hence an inverse relationship is expected between BMI and the probability of sickness. However, the coefficient on BMI has an unexpected positive sign and is significant at the 10% level. The effect of temperature is positive but not significant. Duration of exposure shows a negative sign and is contrary to expectations. However, since the coefficient is not significant, the perverse sign can be ignored.

The expected predicted probabilities of illness estimated from the Probit model are presented in Table 7. The probability estimate for the applicator group (0.72) is significantly different statistically from that of the applicator group during the non-applying days (0.64) and from that of the agricultural labor group (0.63). The probability estimates in the latter two cases are the same. A reduction in dose of all chemicals by 10% or a 25% reduction in the dose of the most toxic chemical (red) yields the same effect, reducing the probability of sickness during application days to 0.61. This probability reduces to 0.56 if all chemical doses are reduced by 25 %. Hence, if people can be persuaded to substitute the safest chemical for the most toxic, the probability of falling sick as a result of exposure is again 0.64, which is identical to the probability of falling sick when not exposed.

5.2. The Welfare Loss

The adaptive response to sickness by exposure to pesticides varies depending upon the severity of the symptom and its type. The general practice, when the symptoms are mild, is to resort to home remedies and to depend on self-medication of common allopathic drugs and rest. However, when the symptoms are moderate, physicians are formally consulted and their advice followed. When the symptoms are severe, workers are often admitted to hospital. The estimated average health cost for the sample is presented in T able 7. The welfare losses recorded in this Table reflect the costs of illness as well as the probability of falling sick.

Table 7 indicates that the health costs for the applicators during both non- applying days and agricultural laborers days are the same (Rs.33 per day). Health costs for applicators are Rs. 41 per day. The difference, (Rs.38 (US$ 0.86),) is the cost due to pesticide exposure. This amounts to 24 % of the average daily earnings from pesticide application. Health costs associated with other types of work amount to only 1.5% of their average daily earnings. Assuming 42 spraying days per year, the average annual welfare loss to an applicator from pesticide exposure amounts to Rs.1596 (US$ 36) per applicator.

The total population of farm workers in Kerala is reported to be16,53,601 (according to the 2001 Census) of which 11,03,317 are males. Only male workers undertake pesticide application work. On the basis of this data, we could make the modest assumption that 10% of these male workers undertake pesticide application work and that the average spraying work days of a worker is 42 days per year. This would lead us to estimate that the welfare loss from total acute health damages from pesticide exposure is Rs 18 crores per year.

Our study results reinforce findings from other pesticide exposure studies. For example, Wilson (2002), following the cost-of-illness approach, estimated that a farmer in Sri Lanka on an average incurs a cost equal to a month's income every year due to exposure to pesticides. In our study, the annual welfare loss is equal to half a month's income per year .(Assuming: 42 days of spraying and 156 days of other work). In the Philippines, the health cost of farmers exposed to pesticides is reported to be 61% higher than that of unexposed farmers (Pingali, et al., 1995). In our study, this difference is much higher. It is 14 times more than that for those not exposed. Our findings are also rather high compared to some recent estimates from Nepal (Atreya,2007). This can be attributed to the generally high level of insecticide use in Kuttanad (more of organo-phosphates) compared to fungicides, the high temperature gradient, the longer work hours, the higher wages and the higher expense associated with medical care.

Through effective awareness creation programs or other policy measures , it is possible to reduce the concentration of spray fluid from the current level by 10%, which would reduce the the welfare loss by 16%. The same effect can be generated by a concerted effort to reduce the dose of the most toxic category of chemicals (red) by 25%. If this is completely replaced by the safest pesticides, the loss can be reduced by 13%. Dose reduction can be achieved either through restricting the quantity of formulation or by merely increasing the dilution of the spray fluid via more water. In our sample, the quantity of water used was observed to be much below the recommended level while the quantity of chemicals used was above the scientifically recommended levels by 17-233%. An extension strategy focusing on this aspect alone would result in an improvement in the health of the applicator without incurring any additional private cost. One way of achieving this is through the targeted training of pesticide applicators. Our study indicates that none of the applicators have had any scientific training in pesticide handling and use. The study also revealed that they had wrong perceptions about the toxicity of the pesticides they handled.

6. Conclusions

Occupational exposure to pesticides is very common among workers in the agricultural sector in developing countries. Our study suggests that pesticide use is often unscientific at all levels of use—from the selection of chemicals and handling practices to averting behavior. This results in health damages to the extent of Rs 38 per day (US$ 0.86) per individual. These costs can also be reduced by improving the spray fluid dilution, that is, by either using more water or going for safer chemicals at a lesser quantity, or a combination of both. We note that these costs are a conservative estimate because they do not take into account long-term chronic illnesses, public expenditure on health care and are only based on self-reported symptoms.

Our study shows that any program with a Rs 18 crores investment for improving the welfare of this group of farm workers can be economically justified. Just as the State Factories and Boilers Department assures the safety and health of industrial workers handling hazardous materials in the case of industries, the State Department of Agriculture could initiate programs with a similar objective. The existing welfare fund board for agricultural laborers could also institute a special component for pesticide applicators.

Support could be provided by imparting training in safe-handling of pesticides and adoption of scientific dose, subsidized supply of protective gear, and awareness-creation programs.

A labor bank of trained pesticide applicators could be maintained in each panchayat which can serve the farm sector in a better and more efficient manner while minimizing welfare losses. Simultaneously, insurance protection measures for pesticide applicators could be introduced. Insurance companies could use the results of this and other studies for estimating the premium. The state could also bear a part of the premium as the social savings accrued by way of health damages avoided.

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Tables

Table 1: Socio-Economic Profile of the Respondents

Sl No.	Description	Pesticide Applicators			Applicators During non-applying days			Agricultural Labor		
		mean	min	max	mean	min	max	mean	min	max
1	Age (years)	45	23	70	-	-	-	50	30	70
2	Education*	2.26	1	4	-	-	-	1.39	1	4
3	Body Mass Index	21.72	15.57	30.61	-	-	-	22.93	16.36	28.01
4	Duration of Work (hrs/day)									
	a) Agricultural Work	2.18	0.5	5	6.3	1.5	8	5.7	2	9
	b) Non Agrl. Work	-	-	-	3.84	1	8	5.29	3	8
5	Wages (Rs/hour)									
	a) Agricultural Work	73	20	200	30	14	107	30	13	125
	b) Non Agricultural Work	-	-	-	52	17	125	36	25	87.5
6	Average earnings per day (Rs/hr)									
	a) Agricultural Work	159	10	1000	192	21	856	170	27	1125
	b) Non Agricultural Work	-	-	-	198	17	1000	192	75	700

**up to 4 years schooling =1, up to 7 years schooling = 2, up to and above 10 years schooling =3*

Table 2: Pesticides in Rice Production in Kuttanad

SL No.	Trade name	Active Ingredient	Chemical Group	Recommended Dosage / per ha	Average level of application	Excess (%)
Insecticide						
1	Asataf	Acephate	OP	800 gm	1467	83.38
2	Ambush	Synth.Pyrethroid	SP	250 gm	553	121.20
3	Atom	Imidaclorprid	Neonicotinyles	150 ml	500	233.33
4	Dimecron	Phosmamidon	OP	250 ml	605	142.00
5	Ekalux	Quinalphos	OP	750 ml	1073	43.07
6	Hostathion	Triazaphos	OP	625 ml	878	40.48
7	Karate	Lamdacyhalothrin	SP	625 ml	1648	163.68
8	kargill 400	Hostathion	OP	625 ml	1440	130.40
9	Lanite	Acephate	OC	800 ml	1482	85.25
10	Lindane	BHC	OC	2000 gm	2933	46.65
11	Malathion	Mercaptothion	OP	1000 ml	1527	52.70
12	Metacid	Methyl parathion	OP	500 ml	773	54.60
13	Monocrotophos	Monocrotophos	OP	600 ml	1535	155.83
14	Nuvacron	Monocrotophos	OP	600 ml	769	28.16
15	Rogor	Dimethoate	OP	1000 ml	1235	23.50
16	Sevin	Carbaryl	Carbamate	2000 gm	4199	109.95
17	Tatamida	Imidachlorprid	Neonicotinyles	150 ml	367	144.67
18	Tatareeva	Lamdacyhalothrin	SP	625 ml	1180	88.80
19	Trebone	Ethophenprox	SP	1500 ml	2109	40.60
Weedicide						
20	2,4-D	Fernoxone	Phenoxy	1200 gm	680	-43.33
21	Almix	Metsulfuron methyl and Chlorimuron ethyl	Alkanoics Sulphonyl Ureas	20 gm	62	210.00
22	Clincher	Cyhalofop butyl Alkanoics	Phenoxy	1000 ml	1342	34.20
Fungicide						
23	Contaf	Hexaconazol	Triazole	800 ml	940	17.50
24	Bavistin	Carbendazim	Carbamate	500 gm	617	23.40
25	Hinosan	Edephenphos	OP	500 ml	869	73.80
26	Kitazin	Kitazin	OP	500 ml	765	53.00

OP- Organo Phosphates, OC-Organo Chlorines, SP- Synthetic Pyrethroids

Table 3: Health Symptoms as a Result of Pesticide Exposure (No. of cases)

Sl.No	Type of sickness	Pesticide applicators during applying days	Pesticide applicators during non-applying days	Agricultural labors
1.	Eye irritation	147	2	3
2.	Nausea	66	1	15
3	Giddiness	29	2	3
4.	Breathing problems	87	5	3
5.	Fever	20	9	2
6	Dehydration	5	0	0
7	Vomiting	40	0	0
8	Cramps	29	3	0
9	Itching	228	5	2
10	Convulsions	24	0	0
11	Burning sensation	51	0	1
12	Hives	134	13	2
13	Diarrhea	11	0	0
14	Excessive salivation	6	0	1
15	Vision problems	6	0	0
16	Tremor	11	0	0
17	Others	11	55	0
18	No symptom	239	117	69
19	Total sample	1135	212	101

Table 4: Dose Response Function and Determinants of Health Damage

Sl.No	Variables	Expansion	Description	Expected Sign
Dependent Variables				
1	Y	Sick or Not Sick	0= Not Sick 1=Sick	NA
Independent Variables				
1	DRed	DOSE of RED category chemical	$\frac{\text{Quantity of the pesticide applied}}{\text{Quantity of water}}$ X Concentration of the pesticide formulation	
2.	DYellow	DOSE of Yellow category chemical	,,	+
3.	DBlue	DOSE of Blue category chemical	,,	+
4.	DGreen	DOSE of Green category chemical	,,	+
5.	DUR	Duration of exposure	Duration of work (mts) for all category	+
6	TEMP	Temperature (degree Celsius)	Maximum Day temperature in the area	+
7	SMOKE	Smoking habits	0 = if non Smoker 1 = Smoker	+
8	ALCO	Alcohol consumption (0,1)	0 = no consumption 1 = if consumption	+
9	BMI	Body Mass Index	Wt / Ht^2 X 100	?
10	EDU1	Education level	From 5 years of schooling to 7 years schooling	-
11	EDU2	,,	above 7 years of schooling	-
12	AGE	Age	Age in years	+

Table 5: Summary Statistics of Variables used in the Dose-Response Function

SL No.	Variables	Mean	Min	Max
1	Y	.7048	0.00	1.00
2	DRed	61.05	0.00	1000.00
3	DYellow	131.73	0.00	1700.00
4	DBlue	140.47	0.00	1950.00
5	DGreen	1.18	0.00	125.00
6	DUR	284	30.00	540.00
7	TEMP	33.36	29.00	34.60
8	SMOKE	0.53	0.00	1.00
9	ALCO	0.23	0.00	1.00
10	BMI	21.83	15.81	30.61
11	EDU1	0.32	0.00	1.00
12	EDU2	0.02	0.00	1.00

Table 6: Binomial Probit Estimates of Determinants of Health Damage

Variables	Coefficient		Marginal Effect
Const	-1.848698	(-1.13)	-0.622529
DR	.001423894***	(5.944)	0.000480
DY	.0004482059***	(3.613)	0.000151
DB	.0005624209***	(5.429)	0.000189
DG	.001473520	(0.333)	0.000496
DUR	-0.0005954632	(-1.488)	-0.000201
TEMP	0.04112364	(0.869)	0.013848
SMOK	0.4181616***	(5.229)	0.140811
ALCO	-0.06032019	(-0.642)	- 0.020312
BMI	0.03076513 *	(1.663)	0.010360
EDU1	0.09592683	(1.101)	0.032302
EDU2	-0.5834437***	(-2.344)	-0.1964684
No. of observation	1448		-
Log Likelihood function	-823.0797		-
Restricted Log function	-879.7414		-
Chi square	113.3234		-

****significant at 1% level* significant at 10% level*
(Figures in brackets are 't' values)

Table 7: Average Health Cost of Pesticide Exposure

Sl. No	Description	Estimation details	Appl. Non applying days	Applicator Applying Days	Applicator on Applying Days			
					Avg. ALL Doses decreased by 10%	Avg. ALL Doses decreased by 25%	Avg. RED Dose decreased by 25%	Avg. RED Dose replaced by GREEN Dose
1	2	3	4	5	6	7	8	9
1	Probabilities of illness per day	From the dose response function	0.64	0.72	0.61	0.56	0.61	0.64
2.	Average health cost (MC)per episode of illness(Rs)	-	4.00	57	-	-	-	-
3.	Average expected health cost per event of spray / work (Rs)	Row 1 x Row 2	3.00	41	35	32	35	36
4	Health cost due to pesticide exposure(Rs.)	Col.5-col4	-	38	32	29	32	33
5	Total expected health cost per applicator per year@42 spraying days(Rs)	Row 4 x 42	-	1596	1344	1218	1344	1386

APPENDIX A

Presumptive Diagnosis of Health Index Values

Sl.No.	BMI Class	Presumptive Diagnosis
1	< 16.0	CED GRADE 2
2	16.0 – 17.0	CED GRADE 3
3	17.0 — 18.5	CED GRADE 1
4	18.5 —20.0	LOW WEIGHT
5	20.0 —25.0	NORMAL
6	25.0 —30.0	OBESE GRADE1
7	> 30.0	OBESE GRADE 2

Source: Naidu, et al., (1991)

APPENDIX B

PESTICIDE USE IN RICE PRODUCTION AND HUMAN HEALTH— A STUDY IN KERALA

Department of Agricultural Economics
College of Horticulture
Kerala Agricultural University PO
Thrissur 680 656, Kerala

MAIN SURVEY QUESTIONNAIRE

CODE: .... ***DATE:*** ....

Name & Address of the Respondent (contact information) :
(give contact Tel. No./land mark)

Name of *Padasekharam* :

Total Area of *Padasekharam* :

1. GEOGRAPHIC INFORMATION

Sl.No	Particulars	Details
1	Village (Name, Ward)	
2	Panchayat	
3	Block	
4	Taluk	
5	District	
7	Level of Pesticide Use (High, Medium, Low)	

2. HOUSEHOLD INFORMATION

Sl.No.	* Family Members	Sex	Age(yrs)	***Education	***Occupation
Total					

* *self=1, spouse of head=2, married child=3, spouse of married child=4, unmarried child=5, grand child=6, father/mother/in-laws=7, brother/sister/brother-in-law/sis-in-law/other relatives=8, servants/ other non-relatives=9*

*** *1=Farming, 2=Service, 3=Others.Others include petty works, construction sector, and other site-specific jobs*

** *1. years in schooling: 4yrs; 2. years of schooling: 7 yrs; 3. years of schooling: 10 yrs; 4. pre-degree; 5. graduate; 6. post-graduate; 7. technical education / diploma.*

3. **Please ask about the property (durable goods) that the respondent has in his/her home**

SN	Durable goods	Specification if any (E.g., Mention the type of livestock)	YES =1 or NO = 2	Number	What is the value if you sell it today(This question corresponds to the market for second hand goods in the rural area.)
1	House along with homestead				
2	Livestock				
3	Television				
4	Radio				
5	Bicycle				
6	Motor cycle				
7	Phone				
8	Boats				
9	Improved toilet				
10	Biogas stove				
11	Other pieces of land if any				

4. Farm Information (This information is to assess the income from farm)

Sl. No	Crops	*ownership	Area (Ha)	Season			Production (Kg/Year)	Price per Kg or No
				1	2	3		
1	Rice							
2	Coconut							
3	Arecanut							
4	Vegetables (specify)							
5	Others							

1. Area Owned 2. Area Leased in 3. Area Leased out

5. Employment Details of the Respondent

Sl. No:	Type of work	Average wage rate	Duration of work /day (Hrs)	No. of days of work/week	Season (specify months)
1					
2					
3					
4					

APPENDIX C

Field Diary for Data Collection in the Project "Pesticide Use in Rice Production and Human Heath—A Study in Kerala"

South Asian Network for Development and Environmental Economics (SANDEE) Kerala Agricultural University

Date: .... Day: .... Name of data collector: ....

Name of Applicator: .... Code No: ....

Table 1: Pesticide use in Rice in the summer crop

It will cover all the pesticide application work he has done during the crop season in different fields and the details thereof. The application no. corresponds to each application done by the respondent during that particular day

Application No:	Area covered	Period/ crop stage (Days after planting)	Variety of paddy Trad. Var=1 HYV=2	Ownership Own=1 Hired=2	Type of infestation #	Pesticide used ##	Perceived toxicity ###	Source of purchase Coop.soc=1 Private Dealer=2 Others=3 Qty	Qty. purchased (ml)	Cost (Rs)		Who purchased Applicator=1 Owner=2 Others=3.
										Rs / Unit	Unit value	
1												
2												
3												
4												
5												
6												

\# *1. rice stem borer, 2. gall midge, 3. rice bug, 4. leaf folder, 5. BPH, 6. rice case worm, 7. rice swarming caterpillar, 8. rice hopper, 9. rice thrips, 10. whorl maggots, 11. leaf hopper, 12. rice mealy bug, 13. rice root nematode, 14. rice cyst nematode, 15. blast, 16. brown spot, 17. narrow brown leaf spot, 18. sheath blight, 19. stalk burn, 20. leaf scald, 21. BLB, 22. black leaf steak, 23. foot rot, 24. sheath rot, 25. viral disease, 26. tungro, 27. yellow dwarf. 28. grassery stunt, 29. ragger stunt, 30. false smut, 31. udbatta, 32. Others (specify), 33. Prophylactic*

##1. 2,4,D, 2. dimecran, 3. ekulex, 4. metacid, 5. nuvacron, 6. bavistin, 7. hinosan, 8. Others (specify)

1=low, 2=medium, 3=high.

Table 2: Spraying Details

Application no.	Type of sprayer Type capacity (lt)	Source of sprayer Hired=1O owned=2	If hired, charge (Rs)	Time spent on preparing (Hrs)	Amt. of water used (lit.)	Source of water	Qty of pesticide used (ml.)	Method of mixing**
1								
2								
3								
4								
5								
6								

***Mix in a separate container and pour to the sprayer 2. Mix in the sprayer itself*

Table: 2 continued ...

Application no.	Any one to assist you Y=1 , N=0	If YType of assistance*	Duration of spray(hrs)	Wage received		Value of wage in kind for Appli/assistant (Rs)	
				Appl.	Asst.	Appl.	Asst.
1							
2							
3							
4							
5							
6							

** For mixing only=1, For spraying only=2, For both=*

Table 3: Mitigating Behavior

Application no.	Did you use any protection gear Y=1 , N=0	If yes, specify the type#	Source Free-1, Purchased-2	If cost of that item	
				Year of purchase	Cost
1					
2					
3					
4					
5					
6					

\# *0=nothing; 1=leg care: boots/shoes/others, 2=Head cover: hat, helmet, others, 3=eye-care: glasses, others, 4=body cover: full sleeved shirt, others, 5=hand care: gloves, others, 6=face care: mask, others, 7=Leg care: Full length trousers, dhoti, others, 8= Others (specify)*

Table 4: Health Effects

Application no.	Did you feel any discomfort after your spraying Y=1,N=2	If 1, Specify the type *	How long did the symptom last (hrs)	Did you adopt any treatment for that ? Yes-1, No-2	If yes, system of medicine #	Whether hospitalized or not. If yes, no. of days	Medical Expenses			
							Doctor's fee	Medicines	Lab. Tests	Hospital expenses
1										
2										
3										
4										
5										
6										

* *1. Eye irritation, 2. Nausea, 3.Giddiness, 4. Shortness of breath, 5. Fever, 6.Dehydration, 7.Vomitting, 8.Cramps, 9.Itching, 10. Convulsion, 11. Burnt feel, 12. Skin irritation, 13. Diarrhea, 14. Excessive salivation, 15.Blurred vision, 16.Tremor, 17. Others*

\# *1. Allopathic, 2.Ayurvedic, 3.Siddha, 4.Unani, 5. Home Remedies*

Table 5a: Health Cost

Application no.	Related traveling expenses	Related dietary expenses	Loss of work days	Substitution by family labor and loss of time in his/her work	Income lost due to this	Approx: crop damage due to lack of supervision specify	Estimated loss	Others if any, specify
1								
2								
3								
4								
5								
6								

Table 5 b: Health cost, if system of Home Remedies

Material used	Fuel for cooking	Market price	Time spent on preparing	Total cost	Local *vaidyan's* fee if any

APPENDIX D

Field Diary for Data Collection in the Project "Pesticide Use in Rice Production and Human Heath—A Study in Kerala"

South Asian Network for Development and Environmental Economics (SANDEE)

Kerala Agricultural University

(For applicators when they are engaged in other work, NOT spraying)

Name of Field Assistant

Part I

Name:

Address:

Location:

Code no:

PART II

Table 1: Employment Details

Date	Type of work	Duration (hrs)	Wages(Rs)

Table 2: Health Effects

Date	Did you feel any discomfort after your spraying Y=1,N=2	If 1, Specify the type *	How long did the symptom last (hrs)	Did you adopt any treatment for that ? Yes-1, No-2	If yes, system of medicine #	Whether hospitalized or not. If yes, no. of days	Medical Expenses			
							Doctor's fee	medicines	Lab. Tests	Hospital expenses

* *1.Eye irritation, 2. Nausea, 3. Giddiness, 4. Shortness of breath, 5. Fever, 6. Dehydration, 7.Vomitting, 8.Cramps, 9. Itching, 10. Convulsion, 11.Burnt feel, 12. Skin irritation, 13. Diarrhea, 14. Excessive salivation, 15. Blurred vision, 16. Tremor, 17. Others*

\# *1. Allopathic, 2. Ayurvedic, 3. Siddha, 4. Unani, 5. Home Remedies*

Table 3: Health Cost

Date	Related traveling expenses	Related dietary expenses	Loss of work days	Substitution by family labor and loss of time in his/ her work	Income lost due to this	Approx: crop damage due to lack of supervision specify	Estimated loss	Others if any, specify

Table 4:

Health cost, if system of Home Remedies					
Material used	**Fuel for cooking**	**Market price**	**Time spent on preparing**	**Total cost**	**Local *vaidyan's* fee if any**

APPENDIX E

Field Diary for Data Collection in the Project "Pesticide Use in Rice Production and Human Heath—A Study in Kerala"

South Asian Network for Development and Environmental Economics (SANDEE)
Kerala Agricultural University

(Questionnaire for Data Collection from Agricultural laborers)

Part I Name of Field Assistant:

Name:

Address:

Location:

Code no:

Part II

Table 1: Employment Details

Date	Type of work	Duration (hrs)	Wages(Rs)

Table 2: Health Effects

Date	Did you feel any discomfort after your spraying Y=1, N=2	If 1, Specify the type *	How long did the symptom last (hrs)	Did you adopt any treatment for that ? Yes-1, No-2	If yes, system of medicine #	Whether hospitalized or not. If yes, no. of days	Medical Expenses			
							Doctor's fee	medicines	Lab. Tests	Hospital expenses

* *1.Eye irritation, 2. Nausea, 3. Giddiness, 4. Shortness of breath, 5. Fever, 6. Dehydration, 7.Vomitting, 8.Cramps, 9. Itching, 10. Convulsion, 11.Burnt feel, 12. Skin irritation, 13. Diarrhea, 14. Excessive salivation, 15. Blurred vision, 16. Tremor, 17. Others*

\# *1. Allopathic, 2. Ayurvedic, 3. Siddha, 4. Unani, 5. Home Remedies*

Table 3: Health Cost

Date	Related traveling expenses	Related dietary expenses	Loss of work days	Substitution by family labor and loss of time in his/her work	Income lost due to this	Approx: crop damage due to lack of supervision specify	Estimated loss	Others if any, specify

Table 4:

Health cost, if system of Home Remedies					
Material used	Fuel for cooking	Market price	Time spent on preparing	Total cost	Local *vaidyan's* fee if any

FIGURES

Fig 1: Pesticide consumption pattern in India

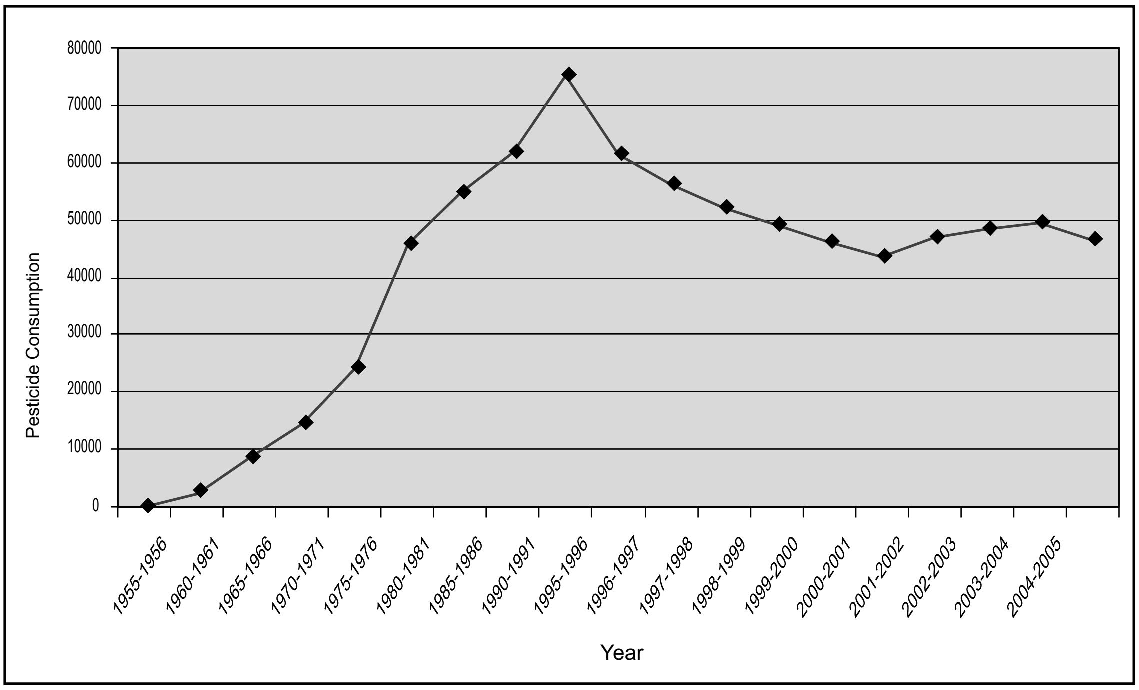


Fig 2: Consumption of Pesticides in Kerala (tonnes)

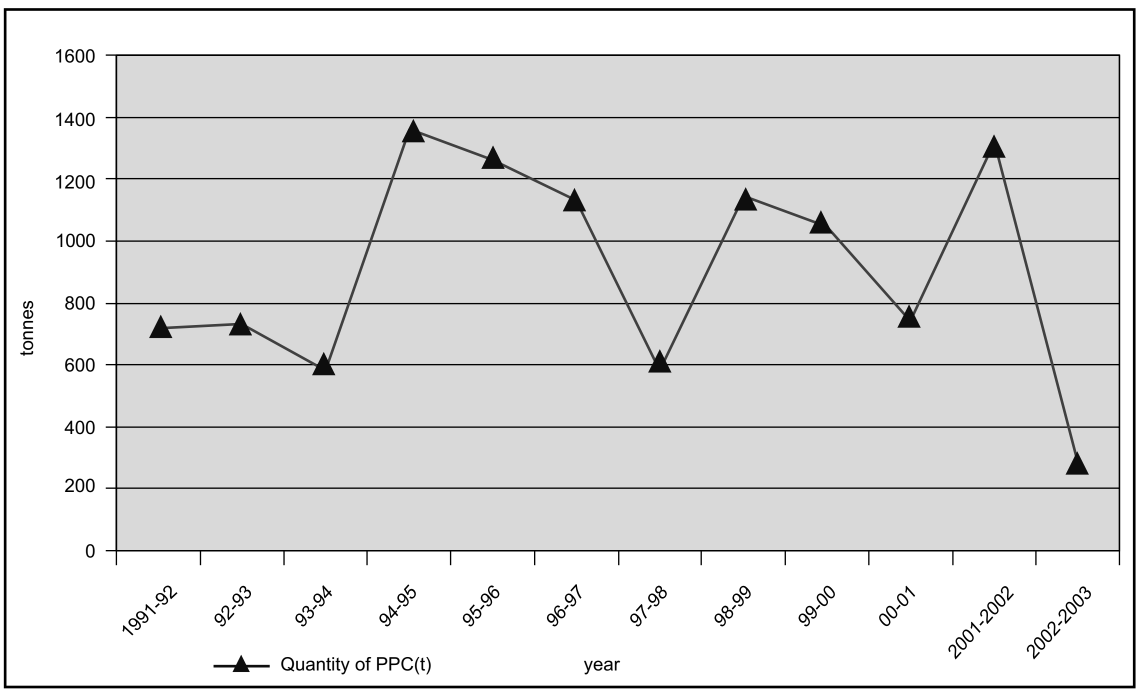


Fig 3: Area covered by Pesticides in Kerala (lakh ha)

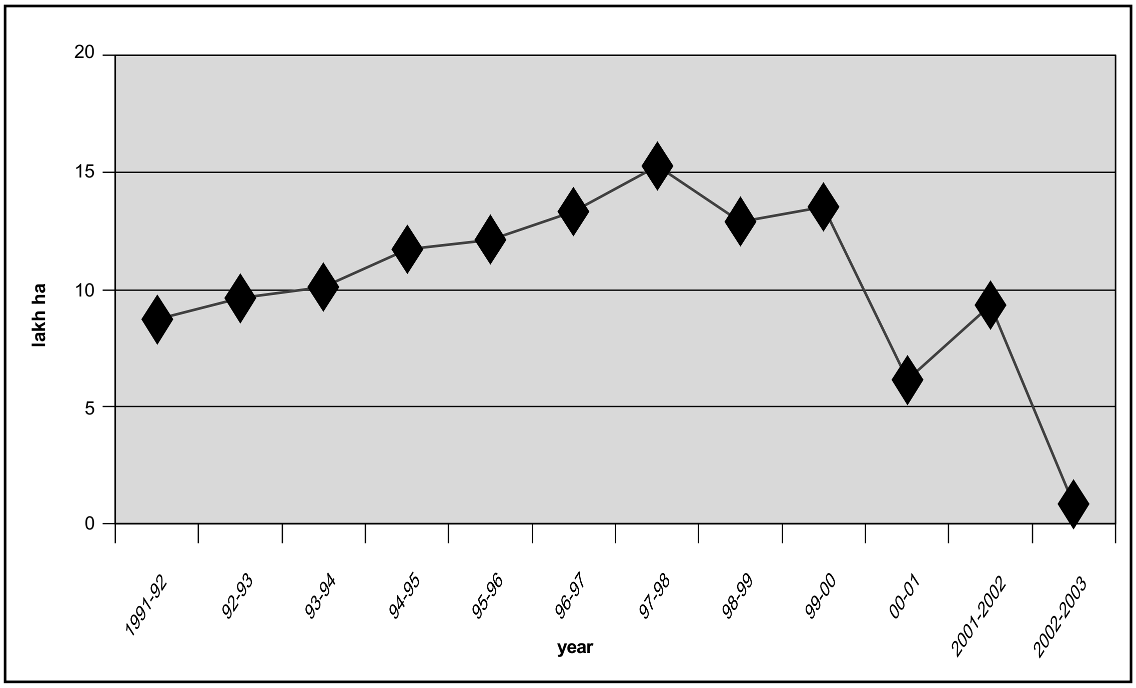
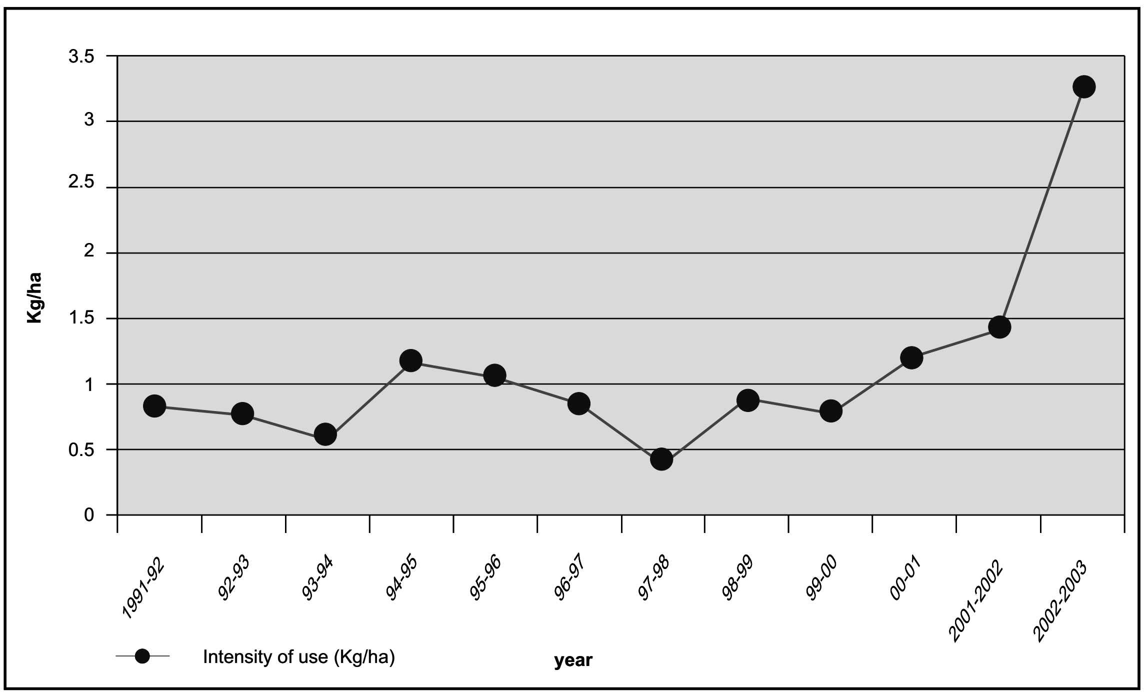


Fig 4: Intensity of use in Kerala (Kg/ha)



Pesticide Use in the Rice Bowl of Kerala: Health Costs and Policy Options

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Abstract

This study examines pesticide use in Kuttanad, India, an ecologically sensitive area often referred to as the rice bowl of Kerala. Using primary data collected from pesticide applicators and farm labor, the study assesses short-term health costs associated with pesticide exposure. The study finds that the toxicity level and dose of pesticides can exert a significant effect on the health of pesticide applicators. The average expected health costs from pesticide exposure are Rs. 38 ((US $ 0.86) per day) or 24 %approximately a quarter of the average daily earnings of the applicator.

The study finds that health costs can be mitigated considerably by reducing the dose of pesticides used. For example, a 25% reduction in either the dose of the most toxic chemical used, or in all pesticide doses, results in a If the dose of the most toxic chemicals used is reduced by 25%, health costs decrease by some 16% and 24% reduction in health costs respectively. A 24% reduction in costs can be realized if all pesticide doses are reduced by 25%. Dose reduction is a desirable and feasible strategy that, and can be achieved either by restricting the quantity of pesticide used or by diluting the amount sprayed with the recommended levels of water. Less than 2% of the applicators understood the toxicity levels of the pesticides they used. Thus, there is ample scope for reducing pesticide exposure through training and agricultural extension services.

Key Words: Pesticide Exposure, Dose-Response Functions, Cost-of-Illness, India