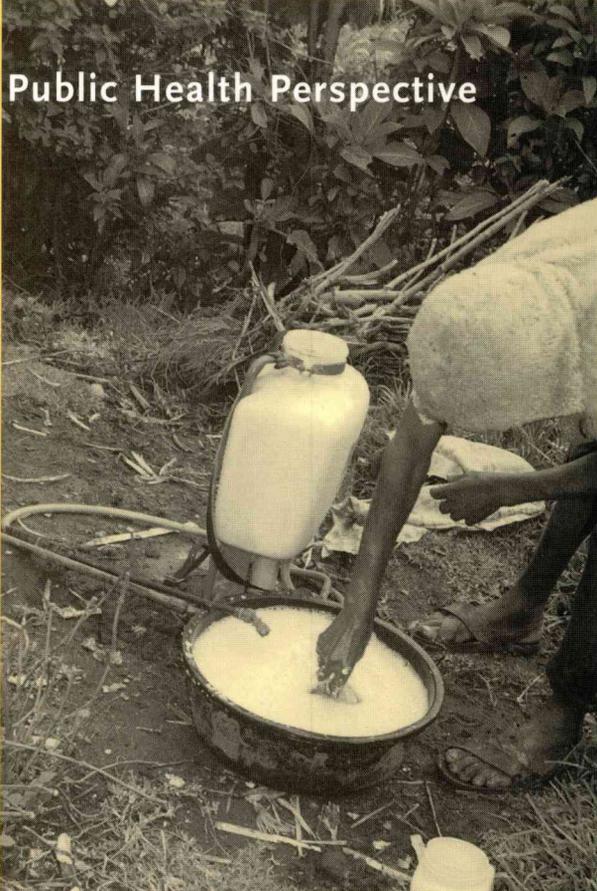


# Occupational Pesticide Exposure among Kenyan Agricultural Workers

An Epidemiological and Public Health Perspective



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A. Ohayo-Mitoko

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**an epidemiological and public health perspective**

**Grace J.A. Ohayo-Mitoko**

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# **Occupational Pesticide Exposure among Kenyan Agricultural Workers**

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**Grace J.A. Ohayo-Mitoko**

## **Proefschrift**

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Chemical poisoning is real and is a growing threat to human lives and to our environment. But the sad fact is that we are not totally aware that it exists. *Edwin Daiwey, "Insecticides in the Third World: Death is Another Export of the Industrialized World", Feb 23, 1980.*

*This thesis is dedicated to my family;  
my parents Juliana and Gordon Ohayo,  
my husband Micah Mitoko and  
my children, Micah Jr., Christine and Trufosa.*

...No warranty of any kind, expressed or implied, is made concerning the use of this product. User assumes all risks and liability resulting from handling and use or application. *Industry.*



This study was part of the Kenyan component of a multi-centre epidemiologic survey, the East African Pesticides Project. The general objective was to assess the health hazards posed by pesticide handling, storage and use in agricultural estates and small farms in selected rural agricultural communities in Kenya where cotton, tobacco, flowers and other horticultural crops are grown, with a view to developing strategies for the prevention and control of pesticide poisoning. 666 agricultural workers, 120 agricultural extension workers and 108 health care workers from Naivasha, Wundanyi, Homabay and Migori comprised the study population. It was found that the 370 formulations registered for use in Kenya by the Pest Products Control Board (PCPB), represented 217 active ingredients. About 22% of the volume imported were highly hazardous, 20%, moderately hazardous, 45% slightly hazardous and the rest, unclassified. Acetylcholinesterase inhibition occurred in agricultural workers (390 exposed; 276 unexposed) as a result of exposure to organophosphate and carbamate pesticides. Acetylcholinesterase levels of 29.6% of exposed individuals were depressed to values below 60% of baseline. Workers from Naivasha had the largest inhibition (36%), followed by Homabay (35%), and Wundanyi (33%); workers from Migori had by far, the least inhibition (26%). Empirical modelling techniques were used to identify and quantify factors affecting exposure to cholinesterase-inhibiting pesticides. The models were adequate as they explained 57-70% of the observed variability in acetylcholinesterase. There was no significant difference in personal hygiene practices between areas. Access to a washing and bathing facility had a positive effect while washing hands and bathing was found to be more reactive than proactive. Spraying had a more profound effect on cholinesterase levels than mixing of pesticides. It has also been shown that workers who sprayed less hazardous pesticides had less inhibition than their counterparts who sprayed more toxic pesticides. However, hardly any variability existed in factors such as personal protective devices and hygienic behaviour within areas, thereby limiting the power of the models to detect the effects of these potential factors affecting exposure. The prevalence of symptoms in this population was described in order to relate levels of inhibition to reported symptoms and to evaluate at which inhibition levels symptoms become elevated. The prevalence of symptoms was found to be higher during the high exposure period than during the low exposure period in the exposed subjects. The presence of a relationship between acetylcholinesterase inhibition, acetylcholinesterase level and respiratory, eye and central nervous system symptoms was established. Increased symptom prevalence was observed at acetylcholinesterase levels

## **Abstract**

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which are generally considered as non-adverse. The knowledge, perceptions, observed and reported practices were assessed for the population of agricultural workers. Knowledge was found to be low with regard to safe use of pesticides. For instance the most important route of occupational exposure to pesticides. Practices such as storage, mixing and application were found to be generally poor. Personal hygiene practices were good but the use of personal protective devices was low especially among farmers in Homabay and Migori. The knowledge, perceptions and practices of agricultural extension workers was assessed with respect to safe handling of pesticides. About one third of the extension workers did not know the pesticide operations responsible for poisoning. All the extension workers reported that they were involved with advising on the use of pesticides but only 80% gave advise on safe use. About two thirds of the extension workers felt that pesticides poisoning was a minor problem. They emphasized following of instructions, use of personal protective clothing and devices as well as personal hygiene to prevent poisoning. Knowledge, perceptions and practices of health care workers were also assessed with respect to diagnosis, management and prevention of pesticide poisoning. Only about one fifth of the health care workers thought pesticide poisoning was a major problem in the community. Most of the health care workers were able to provide information on the health aspects of pesticides but less than ten percent of this information was directed at the farmers. Diagnosis of poisoning was found to be difficult with only one third of the health care workers reporting that they had seen at least one case of pesticide poisoning in the duration of time that they worked in this agricultural area. Almost all health care workers reported that they would like information and training as well as drugs and antidotes for the management and treatment of poisoning. Lack of knowledge, poor perceptions and practices at all levels as well as the availability and use of the more toxic pesticides were found to be major factors influencing pesticide poisoning. It is necessary to urgently initiate interventions to address the gaps found. The results of this study will facilitate the development of effective multi-faceted strategies for the management, prevention and control of occupational pesticide exposure in Kenya and other developing countries.



## **Preface**

This thesis is based on the Kenyan component of a four-year multi-centre field study aimed at the prevention and control of pesticide poisonings in East Africa. The East Africa Pesticide Network (EAPN) was a descriptive epidemiologic survey conducted in East Africa (Kenya, Uganda and Tanzania) by scientists from the Kenya Medical Research Institute (KEMRI), Kenya, the Tropical Pesticides Research Institute (TPRI), Tanzania and the Occupational Health and Hygiene Department (OHHD), Ministry of Labour, Uganda. Biological monitoring of exposure of pesticides among farmworkers was carried out and the knowledge, attitudes and practices of farmworkers, agricultural extension workers and health personnel was assessed with a view to developing strategies for the prevention and control to pesticide poisoning in the region. This study was done with financial support and scientific collaboration from the Finnish Institute of Occupational Health (FIOH) of Finland, The International Development Research Center (IDRC) of Canada and Wageningen Agricultural University. This is gratefully acknowledged.

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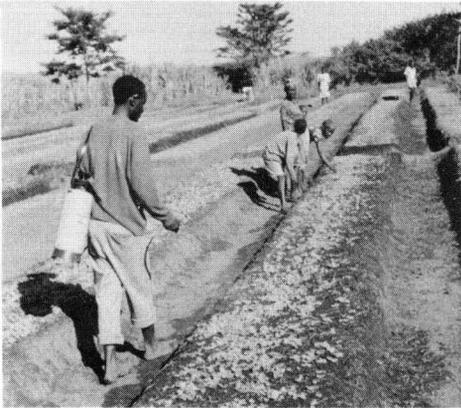
# **PART I**

## **GENERAL INTRODUCTION**



# Chapter 1

## Introduction



## Background

Pesticides<sup>1,2</sup> are widely used for the prevention and control of pests, diseases, weeds, fungi and nematodes (WHO, 1986a) in an effort to reduce crop losses due to pests which are estimated to be in the range of 10-30% in the developed countries and up to 75% in developing countries (WHO/UNEP, 1990; Edwards, 1986). One of the pests responsible for the greatest losses is the locust. Even more significant losses occur after the crop is harvested, caused by pests that attack the stored products, particularly in the Tropics (UNEP, 1981; FAO, 1985a). An increase in the number of pesticides and in the amounts used during the last decade have led to growing attention to possible adverse effects on human health, caused, not only by the active ingredients and associated impurities, but also by solvents, carriers, emulsifiers and other constituents of the formulated product (Al Saleh, 1994). These chemicals, however, pose significant occupational and environmental health risks (Moses 1983; WHO/UNEP 1987; Forget, 1991). Agricultural workers are the largest identifiable occupational group at risk (UNEP, 1986; Davies, 1990), especially pesticide sprayers (Zandstra, 1987). Estimates by WHO indicate that worldwide, three million severe pesticide poisoning cases occur annually (WHO/UNEP 1990). In addition, 25 million symptomatic occupational pesticide poisonings occur among agricultural workers in developing countries (Jeyaratnam, 1990).

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<sup>1</sup>FAO(1986a) defined a pesticide as any substance or mixture of substances intended for preventing, destroying, or controlling any pest, including vectors of human or animal disease, unwanted species of plants or animals causing harm during, or otherwise interfering with, the production, processing, storage, transport, or marketing of food, agricultural commodities, wood and wood products, or animal feedstuffs, or which may be administered to animals for the control of insects, arachnids, or other pests in or on their bodies. The term includes substances intended for use as a plant-growth regulator, defoliant, desiccant, fruit-thinning agent, or an agent for preventing the premature fall of fruit, and or substances applied to crops either before or after harvest to prevent deterioration during storage or transport. Similar definitions have been adopted by the Codex Alimentarius Commission (Codex, 1984) and the Council of Europe (1984). In each case, the term excludes fertilizers, plant and animal nutrients, food additives and animal drugs.

<sup>2</sup>Under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), a pesticide is defined as "any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating, any insects, rodents, nematodes, fungi, or weeds, or any other forms of life declared to be pests, and any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant" (NRC, 1993).

Long-term risks have been poorly described (Davies, 1990; Thompson and Stocks, 1997; De Bleeker et al., 1993) while it is known that some of these pesticides are mutagenic, carcinogenic, teratogenic (Moses, 1986) and immunosuppressive in humans (Repetto and Baliga, 1996).

Epidemiological research to evaluate occupational exposure to pesticides of a population of farmers is complex, since it typically concerns exposure to a mixture of agents. Furthermore, contribution to uptake through the different exposure routes (skin, respiratory and gastrointestinal tract) depends on physicochemical properties of the pesticides, personal factors, environmental and occupational conditions (de Cock, 1995).

In the early years of pesticide use, research on adverse health effects, most often, focused on acute effects and fatal intoxications. Knowledge on adverse effects was mainly based on toxicological data from animal studies and human case reports. More recently, epidemiological studies are carried out on a larger scale and cover a diversity of health endpoints, such as neurotoxic, immunotoxic, carcinogenic, reprotoxic, and developmental effects. Chronic effects of long-term exposure are usually the focus of these studies. Chronic health effects in humans are most likely to result from excessive pesticide exposure that might occur in occupational settings (Baker et al., 1990; Richter et.al, 1992).

The pesticides currently in use involve a wide variety of chemicals, with great differences in their mode of action, uptake by the body, metabolism, elimination from the body and toxicity to humans. Acute toxic effects are easily recognized, whereas effects that result from long-term exposure to low doses are often difficult to distinguish. It should be recognized that, for most pesticides, a dose-effect relationship has been defined, and the effects of pesticides may be detected by measuring minor biochemical changes before the onset of adverse clinical health effects. There may be a threshold below which no effects can be observed (No-observed-effect level) (WHO/UNEP 1990). However, malnutrition, dehydration (Baetjer, 1983; Forget, 1991, Matchaba and Siziya, 1995) and high temperatures (Kagan, 1985), which are common in developing countries, are likely to increase sensitivity to pesticides.

### *Health effects of pesticides*

The occupational health of agricultural workers has not been adequately studied (Moses et al., 1993). Antle et al. (1995) reported that a consistent pattern was established showing that pesticide use had an adverse impact on farmer health and the impairment of farmer health reduced productivity. Occupational exposure of humans to agrichemicals, especially pesticides is common and results in both acute (Ambridge, 1988; WHO/UNEP 1990) and chronic health effects, including acute and chronic neurotoxicity (Taylor et al., 1976; Abou-Donia and Pressig, 1976a, 1976b; Xintaras et al., 1978; Savage, 1988; Maizlish et al., 1988; Eskenazi and Maizlish, 1988; Davies, 1990; Robinson et al., 1993; Kishi et al., 1995), lung damage and respiratory failure (Brown et al., 1989) and male infertility (Wharton et al., 1977, 1979; Restrepo et al., 1990; Rupa et al., 1991; de Cock, 1995). A variety of cancers also have been linked to exposure to various pesticides, particularly haematopoietic cancers (Guzelian, 1980) and soft-tissue sarcomas (IARC, 1988). In addition, there have been reports of aplastic anaemia and related blood dyscrasias being associated with occupational exposure to pesticides. Endocrine disruption (Rutherford, 1996; Colborn et al., 1996) and skin effects such as contact dermatitis and allergic sensitization (Adams, 1983; WHO/UNEP, 1990) have been frequently observed in pesticide workers after exposure to several pesticides. Furthermore, immunologic abnormalities and adverse reproductive and developmental effects due to pesticides have also been reported (Repetto and Baliga, 1996). The health effects associated with pesticides do not appear to be restricted to only a few chemical classes (Sesline et al., 1994; Weisenburger, 1993).

### *Risk classification*

WHO/UNEP (1990) and Council of Europe (1984) have grouped formulated pesticides by degree of hazard and the "hazard class" of a pesticide has now been incorporated into legislation in many countries. Copplestone (1982) reviewed the distribution of technical pesticides among the various hazard classes. Many of the organophosphorus insecticides were considered to be very hazardous. Certain countries have moved some pesticides between categories on the basis of problems peculiar to them; for example, in Malaysia, paraquat has been moved from hazard class II to Ib, because it is highly hazardous under conditions of use in Malaysia and other developing countries (WHO/UNEP, 1990; Van

Wendel de Joode et al., 1996). When two or more pesticides are used simultaneously, they may interact and become either more toxic (synergism or potentiation, as with lindane and heptachlor) or less toxic (antagonism). Interactions of dietary nitrite with pesticides that contain a secondary amine group can result in the formation of nitrosamines, which may be more toxic, mutagenic or carcinogenic (Kearney, 1980; Kaloyanova, 1983). Effects that result from the interaction of pesticides, although hard to quantify, are probably of more importance than is generally recognized.

### *Populations at risk: exposure in different agricultural systems*

For several reasons, the use of pesticides and thus the possible health effects, differ between regions and farming systems. In developing countries, most of the subsistence farmers cater for local needs only. There may be many pest problems in this type of agriculture, but usually, the losses are "accepted" or controlled in traditional ways. Use of pesticides is limited, as the farmers are either not aware of their existence, cannot afford them, or do not feel that they are of value.

In developing countries with commercial agriculture, like Kenya, some pesticides may find their way into the hands of the subsistence farmers, who are unfamiliar with the potential risks and necessary safety measures. The use of pesticides in agriculture in developing countries is thus, very much connected with production for the regional, national, or international markets. The most intensive use of pesticides is in the production of horticultural crops such as flowers, production of tobacco, cotton, soya beans, rice, corn and wheat.

Copplestone (1982) categorised farming systems in developing countries into three groups; plantation farming which is usually monocultural and requiring intensive pest control, cash-cropping which is diverse in both types of crops grown and the size of the holdings and subsistence farming. The smaller the holding and the more the crop is for subsistence, the lower is the likelihood that pesticides will be used. Infact, the crop itself also has an influence. The three crops most vulnerable to insect attack being cotton, rice and horticultural crops. Herbicides tend to be less widely used in all types of agriculture in developing countries, since weeds can be controlled by human effort (Mowbray, 1988).

In plantations, pesticide use may be high but the amount of exposure depends on the quality of management. Pesticides tend to be used on a large scale and applied by employees using aircraft, tractor-driven equipment or sometimes knapsack sprayers. In contrast, the cash-cropping farmers use smaller quantities of pesticides than the plantation farmers, either because of lack of access or because of high costs. The pesticides are usually applied using knapsack sprayers and usually by the farmer himself or a member of his family. For subsistence farmers, there is much less exposure to pesticides because, he cannot often afford the products. They must suffer the crop losses caused by pests, and probably represent the group least exposed to pesticides (Coppelstone, 1982).

### *Factors influencing exposure*

Pesticide hazards appear to be more serious in developing countries, where pesticide use is widespread, where pesticides banned elsewhere because of carcinogenic or other adverse characteristics may be used, where workers and health professionals may not be adequately informed or trained in the recognition and prevention of pesticide poisoning, and where means of reducing exposure, such as personal protective devices, may not be easily available (WHO/UNEP, 1990; Jeyaratnam, 1990).

The application equipment used in developing countries is poorly maintained and supplies are usually inadequate. Pesticides are often applied with inefficient hand-sprayers, ox-drawn sprayers, or dusting equipment, and inadequate protective clothing is used. In addition, many pesticides are applied by people wearing inadequate or unsuitable clothing, which is frequently worn for extensive periods after being contaminated by pesticides. Besides, workers are also exposed as a result of re-entry into sprayed areas. This increases the overall exposure of the individual. Moreover, in hot climates, protective clothing can seldom be used, because the temperature inside the clothing gets so high that the worker suffers. Infact, in many developing countries, the hot climate and the general lack of education make pesticide use dangerous to the operator (Forget, 1991; McConnell and Hruska, 1993).

In developing countries, pesticides are generally applied by farmers and farmworkers (agricultural workers), many of whom have insufficient education and training in the

different methods of application. The farmers often lack awareness of the potential hazards and do not take elementary precautions. For this reason, an effective network of extension and advisory services, which provide technical advice on the safe use of pesticides, can be of great value in preventing health effects. Many developing countries have inadequate or no extension service and advice mainly comes from representatives of pesticide manufacturers. Furthermore, pesticides are often applied at too frequent intervals, particularly when they are first used in a country at which time the yields increase dramatically (WHO/UNEP, 1990).

The labelling and packaging of pesticides in developing countries are often inadequate and inappropriate for the area where they are used. The advice is often written in a language that the user does not understand and the toxicity is explained poorly or not at all. In addition, the appropriate uses of the pesticide are usually not stated clearly and the dosages not specified (Kimani and Mwanthi, 1995). Yet, guidelines on good labelling practices have been published by FAO (1985b). These technical details are of no use when presented to illiterate farmers or if entrusted to agricultural extension workers who may not understand them.

In most developing countries, there is a bewildering range of formulations of the same chemical, often prepared locally. Unscrupulous formulators add diluents or use out-of-date ineffective chemicals. In this connection, it may be noted that the World Bank (1985), in its guidelines for use of pesticides in projects financed by the Bank, recommended that materials that are likely to become widely distributed should be made available only in relatively low-toxicity formulations. The recommendation is based on the concept that complete protection of workers cannot be expected in hot conditions. Water-soluble packages and free-flowing granular and micro-encapsulated formulations are safe to use, although the last two are, at present, very expensive, especially for the small-scale farmer.

#### *Cholinesterase inhibition as an indicator of organophosphate and carbamate exposure*

Organophosphates and carbamates are the most common pesticides used in Kenya (Mbakaya et al., 1994; Partow, 1995) and other developing countries (London and

Myers, 1995) and are responsible for most of the pesticide poisonings reported (Mbakaya et al., 1994; London, 1995). Organophosphates and N-methyl carbamate pesticides inhibit cholinesterase (Kaloyanova, 1982; Lopez-Carillo and Lopez-Cervantes, 1993) causing first, excitation and then depression of the parasympathetic nervous system (Miller and Shah, 1982). Recovery from organophosphate-induced cholinesterase inhibition is more prolonged than recovery from carbamate-induced inhibition which is rapidly reversed, usually within 24 hours (Ames et al, 1989a, 1989b; Vandekar et al, 1974). The enzyme cholinesterase hydrolyses the neurotransmitter acetylcholine at the cholinergic nerve synapses (Hayes, 1982) and its inhibition effects on the nervous system is the most meaningful index of the risk of poisoning. Cholinesterase monitoring usually involves measuring the cholinesterase activity of red blood cells (RBC) or plasma (Wills 1972, Roberts, 1979) from blood samples and is a fairly sensitive method for detecting exposure to organophosphate or carbamate pesticides (Lander and Lings, 1991).

Although baseline blood cholinesterase is subject to considerable intra- and interperson variability (Hayes, 1982; Chu, 1985), cholinesterase activity is often used to corroborate reports of organophosphate and carbamate pesticide overexposure (Ratner et al, 1989, Richter et al, 1986). Because the range of "normal" cholinesterase levels is wide, optimal cholinesterase monitoring requires the periodic comparison of blood cholinesterase activity values with an individual's cholinesterase baseline value established prior to exposure to cholinesterase-inhibiting pesticides (Vandekar, 1980). Inhibition of cholinesterase to levels 60% to 25% of an individual's baseline value (i.e. depressions of 40% to 75% below baseline) may result in respiratory difficulty, unconsciousness, pulmonary oedema and death due to respiratory arrest (Ames et al, 1989a, 1989b; Coye et al, 1987). Inhibition levels are considered to be abnormal (clinically significant) below 60% of baseline cholinesterase level (Ames et al, 1989a, 1989b), necessitating the removal of the individual from exposure until his or her cholinesterase level reverts to, at least, 80% of baseline. Retesting of workers is normally recommended when acetylcholinesterase inhibition is 70% of baseline, which is also the WHO recommended level for removal of workers from exposure (WHO, 1972).

*Surveys of knowledge, perceptions and reported practices (and observations)*

Forget (1991) reported that lack of information at all levels may be one of the most important causative factors of chemical intoxication in developing countries. He also recommended that further research should concentrate on behaviours leading to chemical intoxication. This should be done concurrently with proper prospective and retrospective surveys. In addition, information should be sought relative to the decision processes of import, legislation and licensing. Research and development efforts in appropriate technology and safety devices are also critically needed (Forget, 1991).

**The Project**

This study reports on the Kenyan component of the East African Pesticides Network (EAPN), a descriptive epidemiologic survey conducted in East Africa (Kenya, Uganda, Tanzania). It was conducted by scientists from the Kenya Medical Research Institute (KEMRI), Kenya; the Occupational Health and Hygiene Department (OHHD), Ministry of Labour, Uganda and the Tropical Pesticides Research Institute (TPRI), Tanzania (Ohayo-Mitoko et al, 1996), between 1990 and 1994.

The general objective of this project was to assess the health hazards posed by pesticide handling, storage and use on agricultural estates and small farms in selected communities in Kenya where cotton, tobacco and horticultural crops are grown with a view to developing strategies for the prevention and control of pesticide poisoning in Kenya and elsewhere.

The specific objectives were:

- (a) to assess the intensity of absorption of selected pesticides through the use of biological monitoring techniques and the frequency of symptoms that may be attributable to pesticide absorption.
  
- (b) to assess the knowledge, perceptions and reported practices of agricultural workers with respect to pesticide handling, storage and use.
  
- (c) to observe and evaluate actual patterns of pesticide mixing, storage and application, as

well as the use of personal protective devices, in order to identify the extent of potentially harmful pesticide handling practices.

(d) to assess the knowledge, perceptions and reported practices of agricultural extension workers with respect to the safe handling and use of pesticides.

(e) to assess the knowledge, perceptions and reported practices of health-care workers with respect to the diagnosis, management (treatment) and prevention of pesticide poisoning.

(f) to develop recommendations and guidelines with respect to the safe handling and use of pesticides for consideration by national implementation and regulatory agencies as well as farmers and agricultural workers.

### *The Study Area*

Flower farming in Kenya, especially around Lake Naivasha, is a capital-intensive industry that utilizes large amounts of agro-chemicals, especially pesticides. The most common pesticides used in flower farming are carbamates, organophosphates and herbicides. Study area 1 consisted of ten farms and estates, ranging in size from 100 to 3000 acres, in Naivasha Division of Nakuru District. The crops grown were flowers, French beans, strawberries, grapes and other horticultural crops mainly for export to Europe. There were, however, a few small-scale flower farmers but they were not included in the study. The controls for this area were selected from one large sisal farm in Rongai Division of Nakuru District. This area belongs to the same agro-ecological zone as Area 1 and the agricultural workers on this sisal farm were comparable in socio-economic status to the subjects.

Study area 2 included small-scale horticultural farmers from 14 sub-locations of Wundanyi Division in Taita-Taveta District as subjects and unexposed subsistence farmers from neighbouring farms as controls. The subjects practised intensive horticultural farming almost throughout the year to satisfy the demand for fresh horticultural products by the tourist industry in Mombasa.

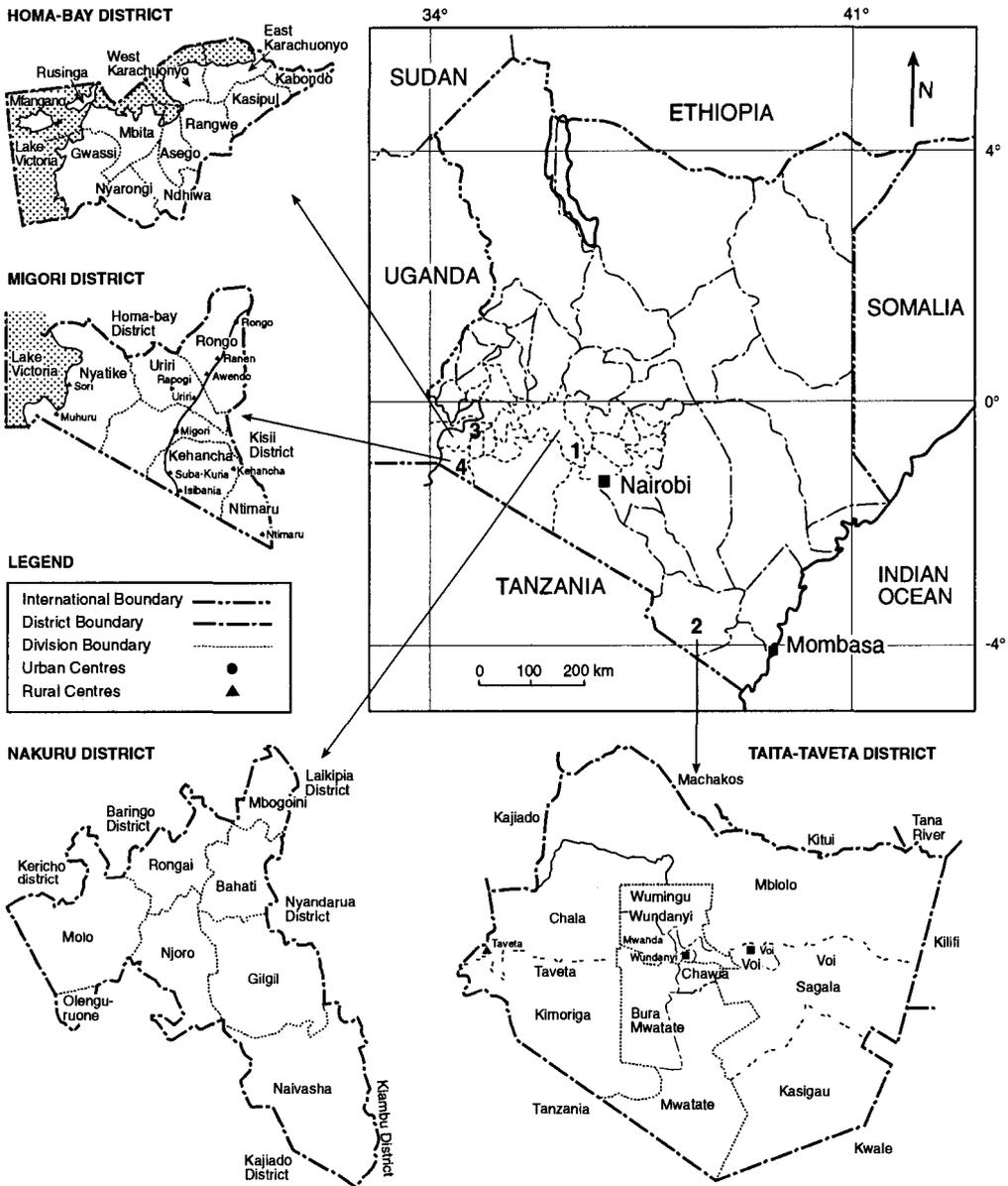


Figure. 1.1. Map of Kenya: The Study Areas

Study area 3 consisted of subsistence farmers from three sub-locations in West Karachuo-nyo Division of Homabay district. These farmers grew maize, beans, millet, sorghum and groundnuts during the long rains (February - July) and cotton as a cash crop during the short rains (September - October), to be harvested in December. There were also a few horticultural farmers along the shores of Lake Victoria who were recruited into the study because they used pesticides in the intensive cultivation of vegetables for sale to inhabitants of surrounding towns. Controls for this area were selected from unexposed subsistence farmers from within these three sub-locations.

Study area 4 consisted of subsistence farmers in Central Migori location of Migori district who grew maize, beans, peas and vegetables without pesticides. In addition, they grew tobacco which was their main cash crop and used high concentrations of pesticides on relatively small plots (usually half-acre). Controls for this area were selected from subsistence farmers in Kabuoch 20 km away, who were not exposed to pesticides at all.

The agricultural extension workers (AEW) and health-care workers (HCW) were recruited from establishments within a 15 km radius of each study area.

### *Contents*

Part I is the general introduction of the thesis and deals with the introduction to the study as well as pesticide management and use in Kenya. Chapter 1 is the introduction and describes the subject background, study objectives, the study area and contents of the thesis. Chapter 2 provides an in-depth country profile on the current state of pesticide management and use in Kenya. It is based on information collected by one of the authors at the beginning of the East African Pesticides Network Project (preparatory phase) and detailed data collected by the second author under the auspices of the World Wide Fund for Nature. It collates a reliable and detailed inventory on the scale of pesticide use in Kenya. In addition, the legal instruments and institutional set-up to regulate and manage pesticide importation, distribution and use, are assessed. The need for more reliable statistics and concerted efforts by all key players in the regulation and control of pesticide imports is underscored.

Part II deals with acetylcholinesterase inhibition and factors affecting inhibition and self-reported health symptoms. Chapter 3 describes the extent of cholinesterase inhibition among Kenyan agricultural workers as a result of occupational exposures to pesticides. In addition, it confirms acetylcholinesterase inhibition as an indicator of occupational exposure to organophosphate and carbamate pesticides and as a marker for exposure to other pesticides. In Chapter 4, empirical models that determine the relationship between factors affecting exposure to pesticides and cholinesterase inhibition, are elaborated. The influence of factors such as type of pesticide used, use of personal protective devices and personal hygiene practices on pesticide exposure, is determined. Chapter 5 describes the prevalence of symptoms in the same population and relates the levels of inhibition data to self-reported symptoms. Inhibition levels at which symptoms become elevated (subclinical) were evaluated.

Part III deals with behaviours leading to pesticide exposure; in order to identify information and knowledge gaps, incorrect perceptions and dangerous practices. Patterns of pesticide handling, knowledge, observed and reported practices of Kenyan agricultural workers, with respect to safe handling and use of pesticides is reported in Chapter 6. This augments previous studies which emphasized only the clinical and physiological aspects of agrochemical poisoning. Knowledge, perceptions and reported practices of agricultural extension workers with respect to the safe use of pesticides are described in Chapter 7. In Chapter 8, knowledge, perceptions and practices of health-care workers (HCW) with respect to diagnosis, management and prevention of pesticide poisoning, are described.

Part IV provides the general conclusions, discussion, and recommendations for interventions. In Chapter 9, the findings of all studies presented are extensively discussed. Conclusions (findings) and recommendations for interventions are outlined in Chapter 10. The PRECEDE-PROCEED model for health promotion and evaluation (Green and Kreuter, 1991) has been used to formulate recommendations for interventions. In addition, it includes the summary of the thesis (in English, Dutch and Kiswahili), acknowledgements and the Author's curriculum vitae.

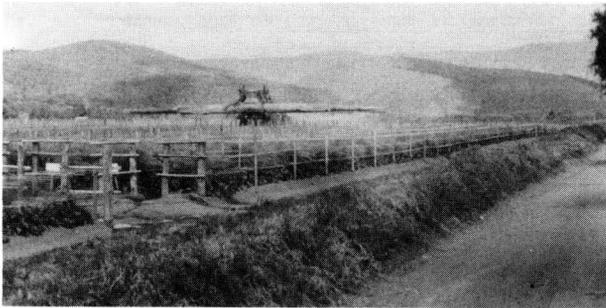


## Chapter 2

# Pesticide management and use in Kenya

Grace JA Ohayo-Mitoko and Hassan Partow

*Adopted and revised from a report by Partow et al. (1995)*



## Abstract

Poor countries; poor statistics. In most developing countries, it is not possible to do more than point to increased use of pesticides and known problems associated with it. It is inconceivable that in countries with high illiteracy rates, no training, no protective clothing, little awareness of hazards and poor or non-existent access to medical facilities, there will not be pesticide-related problems. Most developing countries do not monitor health effects, keep statistics or records of pesticide poisonings or incidents and information, even on importation and use of pesticides within a country is difficult to find.

Pesticide importation records for Kenya between 1989 - 1993 are presented. The 370 formulations registered for use in Kenya by the Pest Control Products Board (PCPB), represent 217 active ingredients. Pesticides classified by WHO as highly hazardous accounted on average for around 22% of the volume imported while those classified as moderately hazardous comprise about 20%, and the less hazardous, 45% of the market. The rest of the imports were unclassified. These statistics hid the fact that a substantial proportion of the pesticides classified by WHO as highly hazardous are imported as technical grade material. This, in effect, meant that after local formulation, the ratio of highly hazardous to less hazardous pesticides used in Kenya was raised significantly. Inorganic chemicals constituted the largest group of pesticides used in the country accounting for 21% of pesticide imports. They were followed by organophosphates (15%), organochlorines (11%), thiocarbamates (7%) and phthalimides (7%). Some pesticides that have been banned or severely restricted in their countries of manufacture were still imported or smuggled into Kenya from neighbouring countries. The need for more reliable statistics and concerted efforts by all the key players in the regulation and control of the importation and use of pesticides is underscored.

## **Introduction**

The general objective of the present chapter is to provide an in-depth country profile on the current state of pesticide management and use in Kenya. It is based on information collected by the first author between 1990 and 1992, mostly during the preparatory phase of the East African Pesticides Network Project (Ohayo-Mitoko et al., 1996) and detailed data collected by the second author between March 1993 and February, 1994, under the auspices of the World Wide Fund for Nature (WWF) (Partow, 1995).

The importance of data collection stems from the need to accurately assess the nature and magnitude of the pesticide problem as a basis for the formulation of a well-informed policy and strategy on the prevention of pesticide poisoning. It also supports the availability of information to the general public; from individual citizens and community leaders to workers, business managers, governmental officials at all levels, scientists, industry representatives and environmental/consumer organizations. This is an important component for consensus and participation by all parties in a comprehensive policy framework on pesticides. Infact, such data could also be used to create awareness in the authorities on the adverse health effects as well as induce them to act on prevention of pesticide poisoning. The utility of a Kenyan study could also extend to other developing countries, particularly African countries.

The specific objectives include collating a reliable and detailed inventory on the scale and patterns of pesticide use in Kenya. This is particularly difficult because of poor statistics and record keeping, information that is not computerised, with much of the data being fragmented, out-of-date and often incomplete and of questionable quality. Moreover, it is especially an arduous task to gain access and retrieve the available country information due to existing strict confidentiality. In addition, this section also seeks to assess the legal instruments and institutional set-up regulating and managing pesticide importation, distribution and use in Kenya.

### ***Country Background***

The republic of Kenya lies on the East Coast of Africa, astride the equator and covers about 575,000 square kilometres. Bisected by the Great Rift Valley, Kenya is a country of

great contrasts in climate, topography and vegetation. The country falls into seven well-defined topographical zones, permitting diverse agricultural systems to flourish. About 20% (106,000 sq. km.) of the land is suitable for agricultural development, with half this area being highly fertile with good soils and adequate reliable rainfall. The other half is of medium potential while another 4.5% is arable but vulnerable to erratic rainfall, frequent droughts and soil erosion. The remainder of the land is only suitable for raising livestock and nomadic herding (Bhusan, 1993). Kenya has two rainy seasons; the "long rains" from March to June and the "short rains" from October to December, and the average rainfall received is between 750 mm and 1000 mm per annum, which is sufficient to sustain a wide variety of crops (Bhusan, 1993).

Kenya's economy is based on agriculture which accounts for 28.7% of the country's Gross Domestic Product (GDP) and provides 50-60% of the export earnings (principally tea, coffee and horticulture) (Bhusan, 1993). About 80% of Kenya's population estimated at 24.4 million in 1993, reside in rural areas and depend on agriculture for their livelihood. Kenya's population growth rate at 3.5 - 4.0% is among the highest in the world (Central Bureau of Statistics, 1993). It is estimated that, of the total labour force of about 8 million, 4-5 million are engaged directly or indirectly in agriculture. The country's increasing population, as well as soaring horticultural exports have put increasing pressure on the limited arable land. As a result, production through the use of agrochemical inputs is anticipated to increase steadily. Kenya's agricultural output has, however, been depressed in the 1990's due to many factors. These include poor rains and prolonged drought, high cost of inputs mainly due to removal of government subsidies, repeated devaluation of the Kenya shilling, falling prices of commodity goods on the international market and localised tribal unrest forcing people from their farms, especially in parts of the Rift Valley and the Western Province. This area contains some of the most fertile land in the country (Partow, 1995).

The agricultural sector has a strong dualistic character. A basic distinction can be made between the large-scale sector with farms greater than 50 ha, and the small-holder sector with farms less than 20 ha. There are conflicting statistics on the proportionate size of the two sectors, but the small-scale sector (20 ha or less) dominates, accounting for about

75% of the farmed area and 85% of agricultural employment (The World Bank, 1986). Agrochemical usage is mainly in the large-scale farming sector, especially those growing plantation crops. This is due to the availability of capital enabling the purchase of these inputs. In addition, the monoculture farming system lends itself more readily suitable for intensive chemical application. Nonetheless, the status of pesticide use in Kenya is changing as small-scale farmers begin to enter a market economy giving them access to a cash base for purchasing pesticides. The small-scale farms now produce more than half of the agricultural products in the market. The phenomenal growth of horticulture over the past decade attests to this transformation and for the increasing reliance of small-scale growers on pesticides to increase and diversify production.

The country's important cash-crop sector, with its intensive reliance on chemical control of pests and plant diseases, is highly developed. Acceleration of agricultural development has been paralleled by an acceleration in farm inputs, especially pesticides and fertilizers, to boost both the quantity and quality of harvests. Horticultural exports have also been steadily increasing and in 1992, for the first time in Kenya's history, foreign exchange earnings from horticulture ranked higher than that brought in by the country's traditional export crop, coffee. Compared to a lot of other African countries, Kenya is at a relatively advanced stage in pesticide management, especially legislation and product registration. It is significant to note that GCPF (Global Crop Protection Federation) chose to undertake its Safe-Use Project in Kenya as a model case for the African continent. There is also some awareness at the official level of the potential danger of pesticides on human health and the environment.

Pesticides are distributed through the free market, through cooperatives, and as Package Aid. Following the break-up of the East African Community, the Ministry of Agriculture started discussions to establish a National Pesticide Management System. This culminated in the enactment of the Pest Control Products Act (No. 4 of 1982). A Board of Management was, thereafter, established (The Pest Control Products Board; PCPB) on May 19th, 1983, and given wide responsibilities for the effective management of pesticides.

### *Pesticide trade and supply*

The use of chemical pesticides in Kenya dates back to the second quarter of this century when inorganic heavy metals, namely copper derivatives, were used to control fungal diseases in the coffee crop. However, it was only after the Second World War that the "systematic use and spraying of pesticides was implemented" in the country (Malaret et al., 1983). Pesticide use is now a well established facet of agricultural production in Kenya and with current agricultural policies to intensify export-crop production, the quantity of pesticides used in agriculture is likely to increase steadily.

The pesticide industry in Kenya, as in most developing countries, is a supply industry dependent on transshipments from overseas. Although there is limited local manufacture of copper fungicides and natural pyrethrum insecticides, these activities account for an insignificant percentage of the total volume of pesticides applied to either agriculture or for public health purposes. In view of its external source of supply, determining national levels of pesticide use is dependent on effective monitoring and recording of import flows. Once the pesticides are in the country, tracing how and where the chemicals are used is virtually impossible due to the lack of controls on the movement of pesticides within Kenya's borders. Regulations on pesticides are, therefore, based on control of importation. Indeed, the Pest Control Products Board's principal and most effective tool in controlling the distribution and use of pesticides, has precisely been through import licensing. However, with new trade liberalisation policies, it will become increasingly difficult for PCPB to regulate and control pesticide imports.

There are a lot of government institutions, at all levels in the regulation of pesticide use and distribution, making it even more difficult to monitor trade in pesticides as well as obtain accurate information on its magnitude. The complicated nature of international pesticide trade, both at exporter and importer ends of the spectrum, has been the subject of several international regulatory control instruments, whose success is yet to be realised.

## **Materials and methods**

### *Research methodology*

The first step in data-collection was to identify the possible information references on pesticide use in the country. A list of information sources was made and relevant establishments consulted (principally government ministries and parastatals). Institutions which had specific executive powers to regulate pesticide use and distribution in the country were repeatedly followed-up during the course of the study. The primary source of information which allowed for the compilation of a computerised data base of the status of pesticide use in Kenya became available following special clearances by Kenya's Ministry of Agriculture, Livestock Development and Marketing. This was through the review of files on pesticide imports licensed by their office. The Ministry's raw data on import records were compiled into a substantial pesticide register which forms the backbone of the computerised inventory and allowed for extensive analysis on the pesticide supply situation in Kenya. Essential information to fill data gaps on the pesticide situation was also obtained from the Pest Control Products Board, the Crop Protection Services Branch, Agricultural Research Institutes, District Agricultural Offices and the Import/Export Excise Department of the Ministry of commerce and Industry.

In view of their external source of supply, any study on the scale of pesticide use in Kenya must rely on import data for its analysis. These are usually obtained from two main sources; the Customs and Excise Department's records which are published by the Central Bureau of Statistics in its Annual Trade Report. The Bureau's classification of imports is based on the Standard International Trade Classification (S.I.T.C) system, under division 59 for "Chemical Materials and Products". This groups pesticides into seven broad categories listed in Table 2.1.

**Table 2.1** SITC headings under which pesticide imports are categorised. This classification does not include the pesticide' active ingredients, does not distinguish between formulated and technical grade material and some pesticides with multiple uses can only be classified under one SITC division.

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Product
Naphthalene Balls
Mosquito Coils
Other Insecticides
Fungicides
Weed-Killers
Anti-sprouting Products and Growth Regulators
Rodenticides and Other Products

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Source: *Central Bureau of Statistics, Kenya*

The Bureau's statistical reports provide data on the annual volume and value for each of the pesticide categories above, indicate the exporting country, as well. This system is concerned basically with the establishment of duty tariffs and does not, therefore, indicate the pesticide's active ingredient, nor does it distinguish between formulated material and technical grade material. In addition, there is a real danger that some pesticides which have multiple uses may be classified under other SITC divisions were not included in the final calculations. Nevertheless, the figures given in the Annual Reports are indicative of the level of pesticide imports and may be valuable for comparative purposes with other sources of pesticide importation.

The second source of information on pesticide importation are unpublished figures compiled by the Pest Control Products Board (PCPB) and these date back to 1986, when the Board first began issuing licences. The Board's estimates indicate the annual volume and value of pesticide imports on the basis of four functional groups; insecticides, acaricides, fungicides, herbicides and others. As with the Customs report, it was not

possible to identify the actual active ingredients or to distinguish formulated products from the technical grade material.

Although the PCPB is responsible for licensing all pesticide imports into the country, they are not usually consulted when arrangements are made with donors to import pesticides under commodity aid programmes. Hence, consignments entering the country through this channel are not included in the PCPB's total estimates of imported pesticides. Direct pesticide importation by government ministries and parastatals may be exempted from licensing by the PCPB under a "letter of release" and would, therefore, not be recorded. Finally, the volume of illicit trade from overseas and from neighbouring countries, especially Tanzania, where pesticides are cheaper because of government subsidies, is quite substantial. Given that some pesticides were smuggled into the country (Partow, 1995), the above figures would only suggest the lower limits of pesticide imports.

The Import Export Licensing Department of the Ministry of Commerce also maintains records of pesticide imports for tariff and foreign exchange control purposes. However, these records are similar to those maintained by the Customs Department as they do not allow for the technical evaluation of pesticide imports. Nevertheless, the computer printouts do identify the importer, the trade name of the commodity, the value of the shipment (in Kenya shillings), but do not indicate the volume of the consignment.

Finally, the Kenya Ports Authority, which handles most of the pesticides from abroad undertakes statistical analysis of imported commodities. However, its annual reports do not systematically distinguish between pesticides and other industrial chemicals.

It should be noted that although import licences are issued by the PCPB, final clearance for each pesticide shipment requires an endorsing stamp from the office of the Permanent Secretary in the Ministry of Agriculture. The Ministry agreed to avail classified records on pesticide imports. The Ministry of Agriculture's documents are probably the most comprehensive source available on pesticide use in the country and it was possible to trace back records of five years (1989 -1993). The time period indicated was sufficient to identify the principal trends of pesticide use in Kenya. The Ministry's documents identify

the date on which the import licence was issued by the Ministry of Agriculture, importer, also indicating the name of the manufacturer, distributor or the local agent, The trade name of the product imported, volume in metric tonnes, kilograms, litres and other measurement units, value of shipment in Kenya shillings and from the 26th of March, 1991, the country of origin was also recorded.

Using the data sources mentioned above, it was possible to piece together a relatively accurate inventory of pesticide imports into Kenya. It should be noted that only scattered work had been done before, on the scale of pesticide use in Kenya; most of which is now outdated. Moreover, much of that research was done at micro-level making it difficult for it to be extrapolated at a national level due to the considerable diversity in Kenya's ecological systems (Partow, 1995). The research database (Partow, 1995) is presently the most reliable and indicative source on the scale and patterns of pesticide use in Kenya.

## Results

### *Research database*

The time period covered by the data-base is from 1989-1993 (Partow, 1995). Information on import levels in 1993 were not available from either the Customs Department or the PCPB at the time of writing. The database, therefore, addresses the most recent time frame of the three sources (5 years). The volume and value of pesticide imports according to the database is reflected in Figures 2.1 and 2.2. After steadily decreasing in volume from 1989 to 1991, pesticide imports increased drastically in 1992 and then again dropped back to 1991 levels. Fungicides comprised the largest volume of pesticides imported, followed by insecticides and acaricides. The proportion of herbicides imported did not increase significantly. Because of the increasing cost of pesticides, there was no decrease in value in imports between 1989 and 1991. Despite the decrease in pesticide volume from 1992 to 1993, the value of imports remained the same. The efficacy of regulatory measures in controlling the pesticide trade in Kenya is seriously put in question when the enforcing government authorities quote divergent figures for the annual volumes imported (Partow, 1995). Moreover, it highlights the poor communication and co-ordination between government bodies on which the control of this trade is essentially dependent. The danger is that the gaps and short-falls in the reporting of pesticide imports (which for

monitoring purposes need to be as rigorous and systematic as possible), leave the country susceptible to being exploited by unscrupulous traders as a dumping ground for unauthorised and unwanted pesticides.

### *Products Registered for Use in Kenya*

As of February 1994, 370 products were registered for use in Kenya; of this figure, 59% were already fully licensed by the PCPB, while the rest (41%) were only provisionally registered pending final recommendations from research trials. Despite the interim status of 41% of the pesticides, there were no specific restrictions on their importation and marketing in the country. Of the registered products, 11% were technical grade concentrates while 89% were imported as ready-made products for commercial sale. The 370 formulations registered by the PCPB represented 217 different active ingredients. Infact, about a quarter of the products sold were actually mixtures of several active constituents (Partow, 1995). It should be noted that there were additional products registered by the Board for "owners-own use" which are not included above. Moreover, PCPB estimated that there were some 250-300 unregistered products currently on the market (Personal communication, Inspector, PCPB). Most of the products registered for use by the board are insecticides (43%), fungicides (22%) and herbicides (18%). Although quantitatively fungicides constitute the principal group of pesticides imported in terms of functional use, products in this category are relatively few, while insecticides, which account for a smaller proportion of the total volume of pesticides imported, comprise a wider variety of products (see Table 2.2).

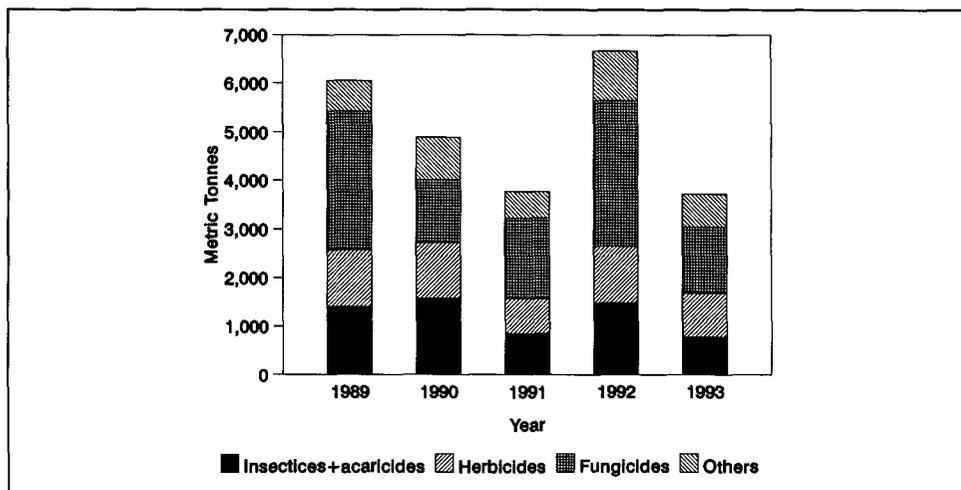


Figure 2.1 Volume of pesticide imports (1989-1993) according to the Research database

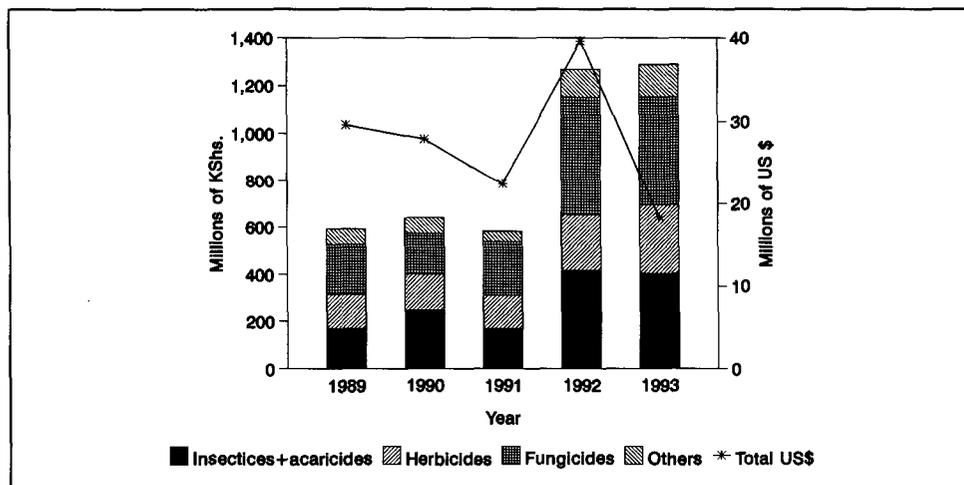


Figure 2.2 Value of pesticide imports (1989-1993) according to the research database.

A significant proportion of the products registered for use in Kenya contain active ingredients which are identified by the "WHO Recommended Classification of Pesticides by Hazard" to be acutely toxic (WHO/ILO/UNEP, 1994). Highly hazardous products refer to WHO Class Ia (extremely hazardous) and Class Ib (highly hazardous) pesticides. It also includes volatile fumigants which, although not classified under any category, are acknowledged by the WHO to be of high hazard potential. Pesticide formulations containing highly hazardous active ingredients accounted for 19% of the products registered by the Board, while those classified as "moderately hazardous" constituted the principle group (36%) of the licensed products.

**Table 2.2** - Functional groups used to register pesticides by the PCPB (1989-1993).

Functional Use	No. of Registered Products	% of Registered Products
Acaricides	11	3
Fungicides	77	22
Herbicides	63	18
Insecticides	156	43
Rodenticides	8	2
Nematicides	12	3
Miticides	13	4
Other	19	5

\*Note: Some pesticide formulations have multiple uses and may fall in more than one functional use category

**Table 2.3** Number of products registered by the PCPB (1989-1993) according to the WHO Classification.

WHO Classification	No. of registered products	% of registered products
Class Ia - Extremely Hazardous	16	4
Class Ib - Highly Hazardous	43	12
Highly hazardous volatile fumigants	11	3
Class II - Moderately Hazardous	132	36
Class III - Slightly Hazardous	71	19
Unlikely to present acute hazard	71	19
Not classified by WHO	26	7

The toxicity rating of an active ingredient is highly dependent on the work conditions in which the formulation is being used, the quantity applied and the extent to which workers handling such products are actually exposed. For instance, if no protective equipment is made available during the mixing and application of chemical concentrates, even a product which is classified by the WHO as 'slightly hazardous" would for all intents and purposes qualify to be hazardous. Toxicity rating is, therefore, not purely a function of scientific evaluation and laboratory experimentation, and needs to be assessed in a social and economic context. It should take into consideration the toxicity of these chemicals under conditions of use in developing countries. Moreover, WHO Classification is based on toxicity and does not fully take into consideration the chronic health impacts of some of these pesticides.

Over the period 1989-1993, an average of 5% of the total volume of pesticides was imported as technical grade material, accounting for 11% of the total value of pesticide imports. While this percentage is relatively small, the quantities and values are significant, particularly in relation to usage levels in the country. However, no statistics were

maintained by the PCPB on the volume of local formulation activities in Kenya and this aspect of the pesticide trade remains almost entirely unchecked.

#### ***Pesticide imports according to WHO Classification***

In terms of the annual quantity imported, highly hazardous pesticides accounted on average for around 22% of total pesticide imports for 1989-1993. While moderately hazardous pesticides made up about 20% of imports, and less hazardous pesticides accounted for 45% of the market (Table 2.4, Figure 2.3).

The statistics, however, show that a substantial proportion of the pesticide volume classified by the WHO as highly hazardous are imported into the country as technical grade material (Table 2.6). This in effect means that, after local formulation, the proportion of highly hazardous pesticides is increased substantially.

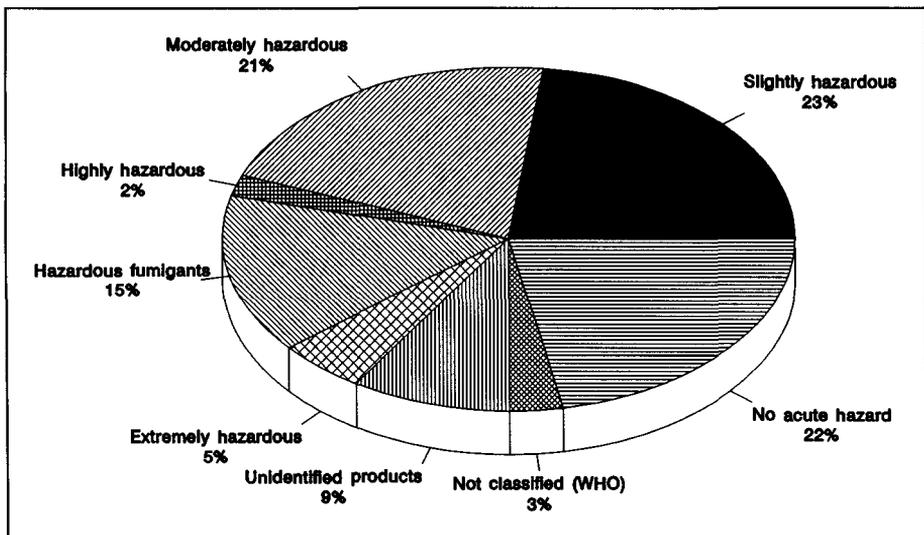
#### ***Pesticide Imports according to major chemical types***

Pesticides active ingredients are classified into chemical groups which have similar structures and groups. The largest group of pesticides used in the country are inorganic chemicals, accounting on average for slightly over a fifth of imports and which are principally made-up of copper derivatives and highly toxic phosphides, such as magnesium and aluminium phosphide (see Table 2.5). Organophosphorus compounds constitute the second major chemical group. About 25% of the organophosphates are imported as technical grade material so that after formulation, they constitute the largest group of pesticides used in Kenya.

**Table 2.4** Average volume of pesticides imported into Kenya (1989-1993) based on WHO toxicity classification.

WHO Class	Tonnes	% of Total
Class Ia - Extremely Hazardous	236	5
Class Ib - Highly Hazardous	123	2
Highly hazardous volatile fumigants	741	15
Class II - Moderately Hazardous	1086	21
Class III - Slightly Hazardous	1147	23
Unlikely to present acute hazard	1107	22
Not classified by WHO	155	3
Unidentified products	465	9

Source: *Partow, 1995*



**Figure 2.3** Percentage of pesticide imports (annual average 1989-1993) according to WHO classification.

Organophosphate pesticides are considered to be the most toxic group of pesticides causing acute and chronic poisoning to farm workers who are occupationally exposed to them. Poisoning from organophosphate compounds interferes with an enzyme, cholinesterase, which is responsible for nerve transmissions. Early symptoms of poisoning include headache, dizziness, and flu-like conditions, while severe poisoning causes difficulties in breathing, unconsciousness and death. Carbamates also have comparable effects on nerve function as organophosphates, cause similar symptoms of poisoning and are the eighth major group of pesticides imported into Kenya.

Dipirydil pesticides, such as the herbicide paraquat, are also highly toxic. Paraquat is almost entirely imported as technical grade material for local formulation purposes. The highly hazardous chemical group is comprised of the ozone-depleting fumigant, methyl bromide which accounted for some 5% of the total imports.

**Table 2.5** Volume of pesticides imported (tonnes) according to chemical type

Chemical group	1989	1990	1991	1992	1993	Grand total (1989-93)	Average % (1989-93)
Inorganic	1975	630	768	1360	564	5297	21.1
Organophosphorus	769	1296	462	632	512	3670	14.6
Organochlorine	464	622	450	847	421	2805	11.2
Thiocarbamate	400	317	307	447	368	1839	7.3
Pthalimide	256	207	327	750	274	1815	7.2
Methyl bromide	348	289	280	255	68	1240	4.9
Chlorophenoxy	174	207	43	131	265	821	3.3
Carbamate	244	108	103	218	91	764	3.0
Aliphatic acid	100	75	125	150	-	450	1.8
Thiadiazine	72	87	60	121	88	428	1.7
Triazine	59	56	66	68	62	310	1.2
Substituted Urea	43	38	80	82	40	293	1.2
Pyrethroid	77	55	40	68	49	289	1.2
Dipyridil	45	34	62	51	14	206	0.8
Triazole	46	19	16	37	39	156	0.6
Other	568	632	415	659	495	2770	11.0
Unidentified products	422	219	169	791	363	1964	7.8

Source: *Partow, 1995*

## Pesticide management...

Table 2.6 Imported technical grade material (tonnes) according to chemical type

Chemical group	1989	1990	1991	1992	1993	Grand total (1989-1993)	Average % (1989-1993)
Organophosphorus	326	152	113	104	91	787	68.5
Pyridyl derivative	45	22	62	51	-	180	15.7
Carbamate	7	12	10	23	50	102	8.9
Organochlorine	15	15	6	10	5	52	4.5
Pyrethroid	3	3	3	7	4	20	1.8
Other	2	1	-	3	2	8	0.7

Source: Partow, 1995

Organochlorine pesticides are the third largest group of chemicals used in Kenya. Although they are not as toxic as organophosphates, they are highly persistent and readily bioaccumulate in the environment. Moreover, many organochlorines cause chronic health problems such as cancer and damage to the reproductive system. Although a small amount is imported as technical grade material, formulation of organochlorine products such as dieldrin and aldrin remain unreported. Other important and widely used pesticides include thiocarbamates, pthalimides and chlorophenoxy compounds. Many compounds in these groups are suspect carcinogens, mutagens and teratogens.

### *The Kenya pesticide industry*

The pesticide market in Kenya is dominated by a few corporations. Eight firms account for nearly 80% of the imports. These are Twiga Chemical Industries Ltd., Rhone-Poulenc (K) Ltd, Bayer (E.A.), Kenya -Swiss Chemical Co. Ltd., Shell Developments (K) Ltd, Farmchem Ltd, Hoechst (E.A.) Ltd., and Amiran (K) Ltd. A fruit canning multinational, Del Monte, is the third largest importer of pesticides. In addition, aid agreements, including commodity aid, which are not regulated by the PCPB, account for another 10-15% of the pesticides imported into Kenya.

Kenya's principal supplier of pesticides was Germany accounting for 22% of Kenya's pesticide requirements, United States (18%), and the United Kingdom (15%). Other pesticide suppliers to Kenya include France, Switzerland, Italy and Israel. Although there have been significant imports from Zambia and Norway, these have consisted of one product; Copper oxychloride. Technical grade material is imported from four countries; the United Kingdom (29%), Germany (25%), Japan (24%) and the Netherlands (11%) (Partow, 1995).

### *Review of pesticides causing concern*

There are a number of pesticides that have been found too hazardous and have either been banned or severely controlled in the manufacturing countries. These include aldrin, dieldrin, heptachlor, toxaphene, lindane, endrin DDT and chlordane. In 1989, the FAO Code of Conduct on the Distribution and Use of Pesticides was revised to directly incorporate provisions for PIC (Prior Informed Consent). At the same time, a similar

amendment was made to UNEP's London Guidelines on the Exchange of Information on Chemicals in International Trade. The International Register for Potentially Toxic Chemicals (IRPTC) in coordination with the FAO are responsible for the administrative and logistical execution of this scheme.

PIC is essentially an information exchange scheme which aims to facilitate the implementation of an internationally endorsed principle: that pesticides which have been banned or severely restricted are not exported without the explicit approval of the importing country. Pesticides included under the PIC procedure, are regulated strictly on health and environmental grounds. However, the scheme also allows for inclusion of pesticide formulations where there is documented evidence that the pesticides pose significant health and safety problems under conditions of use in developing countries. Some of the pesticides that are subject to PIC have been imported and continue to be used in Kenya. These include aldrin and dieldrin, DDT, heptachlor, captafol, dicofol, paraquat and phosphine. Other chemicals in this category, namely 2,4,5,-T was banned by PCPB in 1986 while methyl parathion was banned in 1989 due to high incidences of occupational poisoning in its application. Other products like chlorobenzilate, demeton, hexachlorobenzilate, methoxychlor, mirex and sodium fluoride are not registered with the PCPB and hence their sale and use in Kenya should be prohibited.

#### *"For export only" pesticides*

PIC's information exchange scheme does not address trade in 'unregistered pesticides', including those that have been refused registration for health and environmental reasons. The term "unregistered pesticides" covers a wide category of compounds. These are pesticides which are not authorised for use in a particular country and have never been granted registration status by the concerned country's regulatory authority. They also include pesticides which have been voluntarily withdrawn by the manufacturer from the market and those for which registration renewals may have been denied or whose registration application is pending (Greenpeace and PAN-FRG, 1990).

Lack of a systematic notification procedure on the status of unregistered pesticides has meant that importing countries, especially those with inadequate regulatory mechanisms,

are often caught unaware by the health and environmental effects of the pesticides. Most of the pesticides which fall under this category were imported from Germany and the USA while most of the unregistered technical grade material was imported from the Netherlands. In 1991 and 1992, half the volume of pesticides imported from Germany were composed of chemicals not registered for use in Germany (see Table 2.7). In 1993, the proportion decreased slightly to one third. The major chemical of concern was the organochlorine pesticide 1,3, dichloropropene, a carcinogen and suspect mutagen. The main unregistered pesticide imported from the USA was carbosulfan. Although there were no records of commercial carbosulfan imports in 1993, the chemical was provided to the Ministry of Agriculture under a commodity aid package from Japan. In 1991, 13% of pesticide imports from the US were of unregistered pesticides. However, this figure dropped to 3.7% in 1992 and to 1.6% in 1993 (see Table 2.8). Unauthorised pesticide exports from the Netherlands were also substantial (Table 2.9). In 1991, 8.9% of Dutch exports were made-up of unregistered pesticides, in 1992, the ratio shot up to 44.4% of total exports but dropped to 11.4% in 1993 (see Table 2.9). Other countries also exported to Kenya pesticides not registered for use in their domestic markets. For instance, the UK exported hexaconazole, piperonyl butoxide and sodium dichromite/arsenic pentoxide, while France exported gamma-BHC(51) and L-flamprop-isopropyl. Unregistered shipments from Switzerland included ametryn, iodfenphos, phosphamidon, profenfos, and thiometon.

Table 2.7 Exports of unregistered pesticides (in kgs) from Germany to Kenya, 1991-1993

Active ingredient	Manufacturer in Germany	Importer in Kenya	1991	1992	1993
1,3 Dichloropropene	Dow Chemical Company	Del Monte	411,238	759,800	200,000
Alkylaryl polyglycol Ether	BASF AG	BASF E.A.	-	15,000	6,000
Benodanil	BASF AG	BASF E.A.	1,730	-	-
Bentazone/Atrazine*	BASF AG	BASF E.A.	-	-	15,040
Betacyfluthrin**	BASF AG	BASF E.A.	-	1,950	1,760
Dodemorph-Acetate	BASF AG	BASF E.A.	4,160	3,600	32,640
Fenoxypop-p-ethyl	Hoechst AG	Hoechst E.A.	10,000	20,000	-
Glufosinate-Ammonium	Hoechst AG	Hoechst E.A.	5,000	-	-
Imidacloprid	Bayer AG	Bayer E.A.	-	-	300
Isotridecanol/Aliphatic alcohol	Hoechst AG	Hoechst E.A.	-	1,260	-
Tebuconazole	Bayer AG	Bayer E.A.	8,000	10,000	17,000

Source: *The Pesticides Trust, London.*

\* only Atrazine is not registered for use in Germany

\*\*Imported by Bayer E.A. Ltd. as technical concentrate for local formulation purposes.

**Table 2.8** Exports of unregistered pesticides (in kgs) from USA to Kenya, 1991-1993

Active ingredient	Manufacturer in USA	Importer in Kenya	1991	1992	1993
Alphacypermethrin	FMC	Maramata/ Farmchem	15,000	10,000	-
Carbosulfan	FMC	KGGCU/ Twiga Industries	55,550	15,000	-
Pentachloro-nitrobenzene (PNB)	Uniroyal Co.	Rhone-Poulenc(K)	-	3,000	6,000
Trizophos	Not known	Hoechst E.A(Ltd)	-	8,000	-

Source: *Farm Chemicals Handbook 1993 (Sine C, 1993)*.

The most serious dimension of the pesticide problem in Kenya, as in most developing countries, is due to the occupational hazard of pesticide poisoning. This problem is exacerbated by the fact that there are hardly any restrictions on the availability of highly toxic pesticides to the general public. Other than limited educational sessions on pesticide use to a few targeted groups by the Ministry of Agriculture (through agricultural extension workers) and the recently launched Safe-Use Project (Organized by the Pesticide Industry), Kenya lacks an Applicator Certification Programme. This effectively means that the use of pesticides in the country is unregulated and not monitored.

Both the FAO Code of Conduct and the Amended London Guidelines make reference to pesticides whose safe use is difficult to ensure under prevailing conditions of use in developing countries. However, the PIC criteria for "reportable control actions" is based strictly on health and environmental criteria and exclude pesticides which are subject to severe handling restrictions. The PIC "Guidance for Governments" states that "the restriction of a pesticide by allowing registration for use by special (licensed or certified) applicators only, such as commercial users, professional growers, or by special equipments, such as, boom sprayers only, closed handling systems, will not qualify a chemical for inclusion in PIC (FAO/UNEP, 1991).

**Table 3.9** Exports of unregistered pesticides (in kgs) from the Netherlands to Kenya, 1991- 1993

Active ingredient	Manufacturer in the Netherlands	Importer in Kenya	1991	1992	1993
Atrazine/Ametryn*	Ciba-Geigy	Kenya-Swiss Co.	-	40,000	-
Carbosulfan	Not known	Not known	-	-	10,000
Heptachlor@	Velsicol Co.	Del Monte (K)	-	8,200	10,000
Mancozeb/Metalaxyl	Ciba-Geigy	Kenya-Swiss Co.	-	10,000	-
Monocrotophos/ Alphacypermethrin#	Shell	Shell (K)	9,000	8,640	-
Monocrotophos/ Cypermethrin#	Shell	Shell (K)	-	14,462	-
Quinalphos	Sandoz Agro	Farmchem	-	3,000	-
Thiabendazole	Merck Sharp & Dohme	Shell (K)	-	4,000	-

Source: *The Pesticides Trust, London*

\* Only ametryn is not registered for use in the Netherlands.

@ Technical grade material manufactured in the US; formulated in the Netherlands.

# Only monocrotophos is not registered for use in the Netherlands

From a developing country perspective, where protective clothing and other specialised application techniques and equipment are unsuitable or unavailable, and where highly toxic pesticides are readily sold over the counter and used by a largely untrained, illiterate labour force, these would be among the top priority chemicals for inclusion in PIC.

There are more than 40 pesticides (Partow, 1995) that are for the most part freely available in Kenya but which have been restricted by the Environmental Protection Agency for use only by certified licensed applicators in the United States and for which FAO/UNEP have recommended restrictions on their availability to the general public. It might be safely assumed that pesticides whose use is restricted to well-trained applicators and which require purchasing permits in highly industrialised countries such as the United States, will be problematic in largely rural settings with an illiterate labour force and poor

working conditions. Indeed, at its Seventh Meeting, the FAO/UNEP Joint Group of Experts on PIC acknowledged as feasible, a proposal for the identification of 'problem pesticides' in developing countries and the broadening of reportable actions under PIC to include severe handling restrictions. The principal advantage of such a system would be that 'the responsibility to prove that a product may be used safely rests with the manufacturer, rather than for developing countries to prove that a pesticide is causing problems' (FAO/UNEP, 1994). It also urged the pesticide industry to assume its full responsibilities of product stewardship and to ascertain that its pesticides are being used safely.

### *Pesticide Legislation*

Only about half of the developing countries have effective pesticide legislation. In Africa, the figure drops to twenty-five per cent (Schaefers, 1992a). Despite its deficiencies, the pesticide legislation in Kenya, is considered to be among the more advanced and comprehensive ones on the continent.

Pesticides, from production to distribution, use and sale, impact on various spheres of human activity. The diffused nature of the pesticide life-cycle has meant that its regulation is fragmented over a wide body of jurisprudence. In Kenya, pesticides are subject to general laws, such as those in effect for occupational health and safety standards and those regulating pesticide imports into the country. Furthermore, several Government Acts address pesticides within the larger framework for hazardous chemicals and finally, the Pest Control Products Act is exclusively geared to pesticide marketing and use. It is also imperative that outdated statutes are brought in line with current requirements. Overall, there is an urgent need to systematically coordinate pesticide legislation and extend statutory requirements to include occupational and environmental health as well as prevention of ground and surface water pollution.

### *The Pest Control Products Act*

The Pest Control Products Act (PCPA) of 1982, Chapter 346 of the Laws of Kenya, is the most significant piece of government legislation on pesticides. It replaces the "Control of Pesticides Act", enacted when Kenya was part of the "first" East African Community in 1975. In broad terms, the Act aims to manage and control the trade, manufacture,

distribution and use of pesticides in the country. For pesticide legislation to have the desired impact, five principal conditions must exist. These include the political will to enforce the statutory requirements, establishment of an autonomous regulatory unit acting independently from the particular agenda of any specific Ministry, a functional structure capable of managing pesticide issues across government Ministries and Agencies, fiscal resources and qualified personnel to implement the scheme. In Kenya, most of these prerequisites have not been met. An operative mechanism to implement the provisions of the Act was put in place with the creation of the Pest Control Products Board (PCPB) in 1984, two years after its enactment. However, it was only in 1986 that the Board was able to effectively address the pertinent question of pesticide registration. Referred to as Legal Notices, they specified factors and terms to be fulfilled prior to the registration of pesticide products, licensing of premises where pesticides are manufactured, formulated, packaged, sold and stored, labelling, advertising, packaging and import/export of pesticides. The level of detail demanded in the Legal Notices is variable. While registration requirements are relatively comprehensive, advertising and packaging is only superficially addressed. Labelling standards have been revised by the PCPB to incorporate the use of pictograms, colour coding and expiry dates. These revisions were initiated by GCPF's Safe-Use Project. However, this is not yet mandatory.

Although deregulation of trade was not specifically aimed at agricultural inputs, relevant World Bank/IMF's Structural Adjustment Programme (SAP), promoting trade liberalisation as the route to economic development, have had far-reaching effects on pesticide import documentation. As mentioned previously, the regulation of pesticide distribution and use in Kenya is based, almost entirely, on import control through a licensing system, jointly coordinated by the PCPB and the Ministry of Agriculture. This *modus operandi* was briskly undermined by the World Bank trade liberalisation policy, prompting a series of revisions in import schedules, which began in 1992 and ended in May, 1993. These removed import regulations on most products. In the new schedule, importation does not require prior approval but products are expected to meet technical, phytosanitary, health and environment standards, on their arrival (Laws of Kenya, 1993). This move has literally undermined most of the efforts made over the years to improve the regulation and control of pesticides.

GCPF (Global Crop Protection Federation) has taken practical measures to demonstrate its commitment to the Code. In Africa, Kenya was selected as the pilot country and in close collaboration with the Pesticide Chemical Association of Kenya (PCKA), the Kenya Safe-Use Project (KSUP), was launched in December, 1991. The objective of the Project is "implementation of the FAO Code of Conduct on Pesticides in all its aspects, throughout Kenya (GIFAP, undated). It also aims "to focus the attention of the agrochemical industry on the need to improve its own compliance with the code of conduct" (GIFAP). The core activity of the KSUP is its education and training programme aimed at instructing 400,000 farmers on safe use practices over a three year period. It intends to achieve this through 'training of trainers' strategy, thereby creating a trainer base through the extension services of the Ministry of Agriculture who will, in turn, pass their skills to the farmers. The target is to train 2,000 trainers who will in turn each train 60 farmers per year, giving a total of 120,000 farmers trained each year (GIFAP, undated).

The KSUP's project was originally limited to eight districts in Central and Eastern Provinces and so was not proportionately distributed nationally. Some important agricultural regions, notably the Rift Valley and Western Kenya, were excluded. In addition, the farmers targeted, were mainly small-scale growers whereas workers in the plantation sector, where pesticides are more intensively used, have not been fully involved in this training programme. In terms of project methodology, the FAO has expressed caution of "over-training" at the extension officer level which may fail to filter down to the field staff and by extension, to the farmers themselves. A USAID study concluded that, although GIFAP's training programme must certainly be rated among the most advanced in East Africa, it still falls short of the training necessary if farmers are to use pesticides effectively and safely (Schaefer, 1992b). Education of farmers in safe use cannot be seen as a one-shot exercise that can be attained through the efforts of a single workshop. It should be a consistent and sustainable programme based on a reliable extension service infrastructure, which is lacking in Kenya. Nevertheless, KSUP has promoted safe use, especially through better labelling practices by incorporating pictograms, colour coding and expiry dates into product labels. It has also generated considerable international resource material on safe use. Communication channels, are therefore, needed to disseminate this information.

## Conclusions

Lack of reliable data on the nature of pesticide use in Kenya is a severe handicap for the formulation of an informed national policy on pesticide management and use. Data collection and monitoring of pesticide use should, therefore, be a multi-faceted on-going exercise involving all the institutions and individuals who deal with pesticides.

International and national efforts on safe use have dwelt on regulatory initiatives, whether as national pesticide registration schemes regulating the marketing and distribution practices or setting controls on the international pesticide trade through the notification and information exchange instruments. The overall effectiveness of such regulatory activities to enhance safe-use in developing countries have been limited by lack of administrative and technical back-up to enforce implementation and compliance with statutory stipulations.

Other than product registration and import licensing by the PCPB which were impaired in 1993 by the World Bank's Structural Adjustment Programme, resulting in trade liberalisation, there are no further regulatory mechanisms. This has been exacerbated by the poor record of industry in adherence to the FAO Code. The only exception may be GIFAP's Safe Use Project which has laudable intentions as a short-term geographically-limited endeavour. Its impacts on safe-use practices are insufficient at a national level, especially in the important plantation sector.

Quantitative reduction in pesticide use, especially in WHO Class I and II, is a priority, but is not sufficient in itself. Although reduction may mean fewer applications, it fails to directly address the major concern of occupational safety. It is, therefore, necessary to invest in the development of non-chemical alternatives which promote sustainable agriculture.



## **PART II**

# **DETERMINANTS OF AND SYMPTOMS RELATED TO ACETYLCHOLINESTERASE INHIBITION**

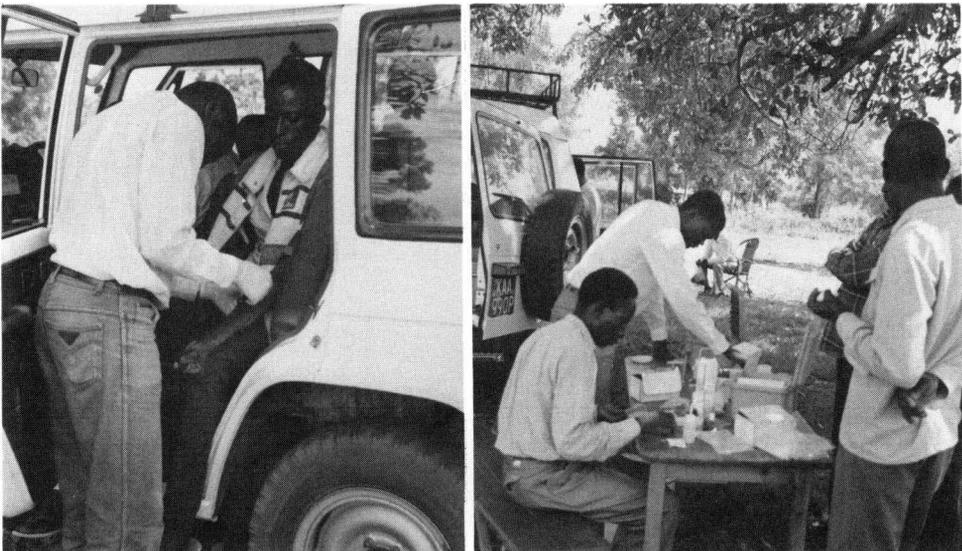


## Chapter 3

# Acetylcholinesterase inhibition as an indicator of organophosphate and carbamate poisoning in Kenyan agricultural workers

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**Abstract**

Acetylcholinesterase inhibition was determined in 666 Kenyan agricultural workers. Out of these, 390 (58.6%) were mainly pesticide applicators exposed to organophosphate and carbamate pesticides and 276(41.4%) unexposed controls from four rural agricultural areas during 1993 and 1994. The results indicate that baseline levels were depressed in the exposed group ( $6.1 \pm 0.84$ ;  $4.09 \pm 0.84$ ) but not in the unexposed group ( $5.83 \pm 0.91$ ;  $5.60 \pm 0.87$ ). Acetylcholinesterase inhibition was found in all exposed individuals and led to a decrease in baseline acetylcholinesterase levels of 33% ( $\pm 12$ ). The unexposed group had a non-significant decrease of only 4% ( $\pm 8\%$ ). The exposed subjects in Naivasha (flower growers) had the largest inhibition (36%) followed by Homabay (cotton-growers) (35%) and Wundanyi (vegetable growers)(33%). Those in Migori (tobacco growers) had, by far, the least inhibition of acetylcholinesterase activity (26%). Acetylcholinesterase activity levels of 115 exposed individuals (29.6%) and no controls were depressed to values below 60% of baseline levels.

The dramatic acetylcholinesterase inhibition observed could lead to chronic clinical and subclinical intoxication. These findings show that acetylcholinesterase inhibition can be used as an indicator of organophosphate and carbamate poisoning in occupationally exposed agricultural workers. It also shows that agricultural workers in Kenya are exposed to cholinesterase inhibiting pesticides. This could lead to adverse health effects. There is, therefore, an urgent need for primary prevention programs to monitor and to address occupational exposures to these hazardous substances in agriculture in Kenya and other developing countries, as well as encourage the use of integrated pest management strategies in crop protection.

## Introduction

Organophosphate(OP) and carbamate pesticides are widely used for the prevention and control of plant pests, diseases, weeds, fungi and nematodes (WHO, 1986a, 1986b) in an effort to reduce crop losses due to pests which are estimated to be in the range of 10-30% in the developed countries and up to 75% in developing countries (WHO/UNEP, 1990). These chemicals, however, pose significant occupational and environmental health risks (Moses 1983; WHO 1987). Agricultural workers are the largest identifiable occupational group at risk (UNEP, 1986; Davies, 1990), especially pesticide sprayers (Zandstra, 1987). Estimates by WHO indicate that worldwide, three million severe pesticide poisoning cases occur annually of which 220,000 are fatal (WHO, 1990), mainly as a result of suicide attempts. In addition, 25 million symptomatic occupational pesticide poisonings occur among agricultural workers in developing countries (Jeyaratnam, 1990). Long-term risks have been poorly described although it is known that some of these pesticides are mutagenic, carcinogenic, teratogenic (Moses, 1986) and immunosuppressive in humans (Repetto and Baliga, 1996).

Organophosphates and N-methyl carbamate pesticides inhibit cholinesterase (Kaloyanova, 1982; Lopez-Carillo and Lopez-Cervantes, 1993) causing first, excitation and then depression of the parasympathetic nervous system (Miller and Shah, 1982). Recovery from organophosphate-induced cholinesterase inhibition is more prolonged than recovery from carbamate-induced inhibition which is rapidly reversed, usually within 24 hours (Ames et al, 1989a, 1989b; Vandekar et al, 1974). The enzyme cholinesterase hydrolyses the neurotransmitter acetylcholine at the cholinergic nerve synapses (Hayes, 1982) and its inhibition effects on the nervous system is the most meaningful index of the risk of poisoning. Cholinesterase monitoring usually involves measuring the cholinesterase activity of red blood cells (RBC) or plasma (Wills 1972, Roberts, 1979) from blood samples and is a fairly sensitive method for detecting exposure to organophosphate or carbamate pesticides (Lander and Lings, 1991).

Although baseline blood cholinesterase is subject to considerable intra- and interperson variability (Hayes, 1982; Chu, 1985), cholinesterase activity is often used to corroborate reports of organophosphate and carbamate pesticide overexposure ( Ratner et al, 1989,

Richter et al, 1986). Because the range of "normal" cholinesterase levels is wide, optimal cholinesterase monitoring requires the periodic comparison of blood cholinesterase activity values with an individual's cholinesterase baseline value established prior to exposure to cholinesterase-inhibiting pesticides (Vandekar, 1980). Inhibition of cholinesterase to levels 60% to 25% of an individual's baseline value (i.e. depressions of 40% to 75% below baseline) may result in respiratory difficulty, unconsciousness, pulmonary oedema and death due to respiratory arrest (Ames et al, 1989a, 1989b; Coye et al, 1987). Inhibition levels are considered to be abnormal (clinically significant) below 60% of baseline cholinesterase level (Ames et al, 1989a, 1989b), necessitating the removal of the individual from exposure until his or her cholinesterase level reverts to, at least, 80% of baseline. Retesting of workers is normally recommended when acetylcholinesterase inhibition is 70% of baseline, which is also the WHO recommended level for removal of workers from exposure (WHO, 1972).

The nature, magnitude and severity of pesticide poisoning in developing countries have not been adequately investigated. However, available data are of great concern. For instance, a registry-based study indicated that 13% of reported pesticide poisonings in Costa Rica between 1980 and 1986 were fatal (Wesseling et al, 1993). Lopez-Carillo and Lopez-Cervantes (1993) also found evidence of subclinical intoxications of agricultural workers by cholinesterase-inhibiting pesticides.

Several studies have been undertaken on cholinesterase inhibition as a result of pesticide use in agriculture (De Peyster et al, 1993; Popendorf, 1990). However, most of these studies have been in developed countries. Studies of pesticide poisoning in developing countries have been few and most of them have addressed the health effects of occupational exposures to pesticides in general (Wesseling et al, 1993; Mwanthi and Kimani, 1993; Mbakaya et al, 1994; Restrepo et al, 1990; Steinberg et al, 1989; Igbedioh, 1991; Khan and Ali, 1993; Rastogi et al, 1989; Lopez de Alba, 1990; Rupa et al, 1991). Only a few have dealt specifically with cholinesterase-inhibiting pesticides (Perold and Bezuidenhout, 1980; Kashyap et al, 1984; Lopez -Carillo and Lopez-Cervantes, 1993).

Determinants of pesticide poisoning in general, and poisoning by cholinesterase-inhibiting pesticides in particular, have not been adequately evaluated nor have systematic prevention strategies for pesticide poisoning been developed. This study was part of the Kenyan component of a multi-centre epidemiologic survey, the East African Pesticides Project (Ohayo-Mitoko et al, 1996). The general objective of this project was to assess the health hazards posed by pesticide handling, storage and use in agricultural estates and small farms in selected rural agricultural communities in Kenya where cotton, tobacco, flowers and other horticultural crops are grown, with a view to developing strategies for the prevention and control of pesticide poisoning. In contrast to previous studies, this was a large cross-sectional study that incorporated follow-up features within its design. Acetylcholinesterase activity was measured during a period of very little or no pesticide application (low-exposure period) and repeated during a period of maximum pesticide application (high-exposure period) for both exposed (subjects) and unexposed (controls) agricultural workers, in effect, providing two sets of controls for the study. The objective of the reported study was to determine the extent of cholinesterase inhibition in Kenyan agricultural workers as a result of occupational exposures to organophosphate and carbamate pesticides and its implications for their health. This paper also addresses acetylcholinesterase inhibition as an indicator of occupational exposure to organophosphate and carbamate pesticides among agricultural workers in four rural agricultural areas of Kenya.

## **Study design, materials and methods**

### *Sampling of farms and estates*

Selection of farms and estates for the study was by multi-stage cluster sampling. Using data available from the Ministry of Agriculture in Kenya and other sources, the investigators compiled a list of farms and estates by crops grown, district size and number of employees. Based on this list, locations, sublocations, farms and estates within the districts were randomly selected. Exposed subjects to be interviewed were randomly selected from workers who mixed and/or sprayed pesticides and those who repaired pesticide application equipment. Controls were randomly selected from farms and estates that did not handle any pesticides at all.

This study had a hybrid design that combined cross-sectional and follow-up design features. It was conducted in four regions of Kenya; Naivasha (1); Wundanyi (2); Homabay (3); and Migori (4) (see Chapter 1, Figure 1.1). Study area 1 consisted of ten farms and estates, ranging in size from 100 to 3000 acres, in Naivasha Division of Nakuru District. The crops grown were flowers, French beans, strawberries, grapes and other horticultural crops mainly for export to Europe. The controls for this area were selected from one large sisal farm in Rongai Division of Nakuru District. This area belongs to the same agro-ecological zone as Area 1 and the agricultural workers on this sisal farm were comparable in socio-economic status to the subjects. Study area 2 included small-scale horticultural farmers from 14 sub-locations of Wundanyi Division in Taita-Taveta District as subjects and unexposed subsistence farmers from neighbouring farms as controls. The subjects practised intensive horticultural farming almost throughout the year to satisfy the demand for fresh horticultural products by the tourist industry in Mombasa. Study area 3 consisted of subsistence farmers from three sub-locations in West Karachuonyo Division of Homabay district. These farmers grew maize, beans, millet, sorghum and groundnuts during the long rains (February - July) and cotton as a cash crop during the short rains (September - October), to be harvested in December. There were also a few horticultural farmers along the shores of Lake Victoria who were recruited into the study because they used pesticides in the intensive cultivation of vegetables for sale to inhabitants of surrounding towns. Controls for this area were selected from unexposed subsistence farmers from within these three sub-locations. Study area 4 consisted of subsistence farmers who grew maize, beans, peas and vegetables without pesticides. In addition, they grew tobacco which was their main cash crop and used high concentrations of pesticides on relatively small plots (usually half-acre). Controls for this area were selected from subsistence farmers 20 km away, who were not exposed to pesticides at all. The selection of farms was done by multi-stage cluster sampling. A preparatory phase was included to optimise the design for data collection.

### *Study group*

Six hundred and twenty-three agricultural workers, mainly applicators during the pesticide application periods, were initially recruited into the study. Of these, 390 subjects were available for follow-up (follow-up rate 62.6%). The reasons for non-participation included

deaths, illness, migration, pregnancy and childbirth, and refusal, as this was a voluntary exercise. On large-scale farms, most of the agricultural workers were employed on temporary terms of service and some had been laid off at the time of testing for high exposure, effectively contributing to the drop-out rates.

### *Control group*

The control group consisted of 515 unexposed agricultural workers. These were sisal workers or subsistence farmers who were not occupationally exposed to pesticides. This group was as comparable to the exposed group as possible, in terms of occupation, nutritional status and socio-economic status. Of the 515, 276 controls were available for follow-up (follow-up rate 53.6%). The reasons for non-participation were similar to those observed in the study group.

### *Study periods*

The initial period during which the least (or no) exposure to pesticides occurred, was designated, the low-exposure period while the follow-up period of maximum pesticide usage was designated the high-exposure period. These two periods were different for the four areas and had been determined during the preparatory phase of the project (Table 3.1).

**Table 3.1** Sampling periods in four study areas of Kenya.

Study area	Low exposure	High exposure
Naivasha	May-June 1993	Nov-Dec 1993
Wundanyi	Oct-Nov 1993	July-August 1993
Homabay	March-April 1993	Sept-Oct 1993
Migori	June-July 1993	Dec-Jan 1994

***Field test procedures for cholinesterase determinations***

A field-testing kit consisting of a portable spectrophotometer and preweighed reagents was used. Acetylcholinesterase activity was determined in the field using venous blood samples. Prior to obtaining blood, all donors washed their hands and arms with soap and water to remove any pesticide contamination. After drying with disposable tissue paper, the skin was swabbed with an alcohol-based tissue swab before a blood sample was taken and immediately analyzed. Acetylcholinesterase activity was determined using a WHO approved field spectrophotometric kit from EQM Research Inc., based on the method of Ellman et al. (Ohayo-Mitoko et al, 1996).

***Low exposure period***

Cholinesterase activity measurements were performed on the subjects and controls to determine baseline levels for these individuals. All cholinesterase activity determinations were performed by two State-certified laboratory technologists (Field Assistants). A 10-ml volume of blood obtained immediately after the work shift by venipuncture was tested in the field using the method described above. The Field Assistants were "blinded" from knowing any information about the individual whose blood samples were being tested.

***High exposure period***

During the period of heavy pesticide application (pre-determined during the preparatory phase of the project), cholinesterase measurements were again performed by the same technologists on the same subjects and controls as in the low exposure period.

***Acetylcholinesterase inhibition***

Two parameters were used to describe inhibition. The first was the ratio of acetylcholinesterase activity levels during high exposure divided by the levels during low exposure. The second was the ratio derived from acetylcholinesterase levels during high exposure, corrected for haemoglobin during high exposure divided by acetylcholinesterase levels during low exposure, corrected for haemoglobin during low exposure. The variables described above are related to acetylcholinesterase activity determined for subjects and controls during low- and high-exposure periods in International Units (IU), micro moles of substrate hydrolysed per millilitre of blood at 25°C.

***Consent to participate and Ethical Considerations***

The study was explained to all study subjects and controls and written consent was obtained from those who agreed to participate. The participants could drop-out whenever they decided to. Study subjects identified as possibly having adverse health effects due to pesticide exposure were informed of the situation and directed for medical treatment. The proposal had been approved by the Ethical Review Committee of the Kenya Medical Research Institute, Nairobi, Kenya.

***Data analysis***

Simple frequencies were obtained, through techniques of univariate analysis. The normality of the distributions for the cholinesterase levels was checked with and without correcting for blood haemoglobin levels. Further analysis of the data included comparisons of independent sample means with Student's t-test. Finally, regression analysis and analysis of variance (ANOVA) were used for multiple comparisons between study areas and for assessments of interactions of variables using SAS software (SAS Version 6.11).

**Results**

Recruitment of exposed subjects and controls had been done during the low exposure period described above. The response rate at the initial recruitment was almost 100%. The overall follow-up rate of subjects was 62.6% while that of controls was 53.6% during the high exposure period. Follow-up rates by area for exposed subjects and controls are shown in Table 3.2.

Table 3.2 Follow-up rates of exposed workers and controls by study area.

Study area	Exposed			Controls		
	Recruited and tested at baseline	Tested in the high-exposure period	% follow-up	Recruited and tested at baseline	Tested at follow-up	% Follow-up
Naivasha	217	154	71.0	166	87	52.4
Wundanyi	137	101	73.7	130	74	57.0
Homabay	88	45	51.1	71	32	45.1
Migori	181	90	49.7	148	83	56.1
Total	623	390	62.6	515	276	53.6

### Acetylcholinesterase inhibition...

**Table 3.3** General characteristics of the study population of pesticide-exposed workers(n=390) and controls(n=276) by gender and study area.

Study area	Gender	Exposed Workers				Controls			
		No.	Mean	SD	No.	Mean	SD	Age (years)	
		Age (years)				Age (years)			
Naivasha	Male	154	27.9	7.2	87	32.2	10.1		
Wundanyi	Male	89	45.0	14.2	33	51.3	11.6		
	Female	12	38.9	7.7	41	42.2	12.9		
Homabay	Male	38	38.9	12.3	31	41.7	13.1		
	Female	7	36.7	7.7	1	58.0	-		
Migori	Male	81	39.0	11.6	69	46.6	14.2		
	Female	9	35.6	7.7	14	37.2	11.6		
All	Male	362	35.7	12.9	220	41.0	14.2		
	Female	28	37.3	7.6	56	41.3	12.7		
Total		390	35.8	12.6	276	41.0	13.9		

In the study population, there was no difference between individuals who were re-tested

(follow-up) and those who were not (drop-out), with regard to age (35.8 vs 37.2 years for subjects; 41.0 vs 40.5 years for controls) socio-economic status, occupation and general level of exposure. There was also no difference between those who stayed and those who dropped out with regard to their cholinesterase levels during periods of low exposure (6.1 vs 6.0 for subjects; 5.8 vs 5.9 for controls). Preliminary tests showed that the results of repeated sampling differed by less than 10%. The remaining study sample consisted of 666 individuals: 390 (58.6%) were subjects (exposed group) and 276 (41.4 %) were controls. Of all the individuals, 582 (87.4 %) were men; 84 (13.6%) were women. The mean age of the controls ( $41.0 \pm 13.9$  years) was considerably higher than that of the subjects ( $35.83 \pm 12.6$  years) (Table 3.3). The general characteristics of the study population are tabulated in Table 3.3.

The Acetylcholinesterase levels were normally distributed for the exposed workers (Shapiro and Wilks,  $w = 0.99$ ;  $p > 0.05$ ), both in the high and low exposure periods. For the control group, these distributions were not normally distributed ( $w = 0.97$ ;  $p < 0.05$ ). However, the distribution of Acetylcholinesterase inhibition levels were normal for both the exposed workers and the controls ( $w = 0.99$  and  $w = 0.98$ , respectively). Table 3.4 depicts the mean levels for acetylcholinesterase activity during low- and high- exposure periods, as well as acetylcholinesterase inhibition. Exposure at baseline for the exposure group was apparently absent. Infact, they had higher baseline levels than the controls. A highly significant difference was detected between the mean acetylcholinesterase activity of exposed agricultural workers during high-exposure ( $4.09 \pm 0.84$ ) and acetylcholinesterase activity of controls ( $5.60 \pm 0.87$ ) for the same period. A dramatic depression of baseline levels was observed in the exposed group ( $6.1 \pm 0.84$  to  $4.09 \pm 0.84$ ) but not in the unexposed group ( $5.83 \pm 0.91$  to  $5.60 \pm 0.87$ )(see also Figure 3.1). Acetylcholinesterase inhibition occurred in all exposed individuals. Furthermore, 115 exposed individuals (29.6%) and no controls (on the basis of uncorrected inhibition) had their acetylcholinesterase levels depressed to values below 60% of baseline levels. Analyses with haemoglobin-corrected acetylcholinesterase inhibition levels showed similar results (data not shown).

**Table 3.4** Acetylcholinesterase activity levels (IU) during low and high exposure periods

and acetylcholinesterase inhibition levels (proportion) for exposed workers and controls (uncorrected for Hb).

Variable	Exposed workers (mean $\pm$ SD)	Controls (mean $\pm$ SD)
Acetylcholinesterase activity levels during low exposure	6.1 $\pm$ 0.84	5.83 $\pm$ 0.91
Acetylcholinesterase activity levels during high exposure	4.09 $\pm$ 0.84	5.60 $\pm$ 0.87*
Acetylcholinesterase inhibition	0.67 $\pm$ 0.12	0.96 $\pm$ 0.08*

\*  $p < 0.001$

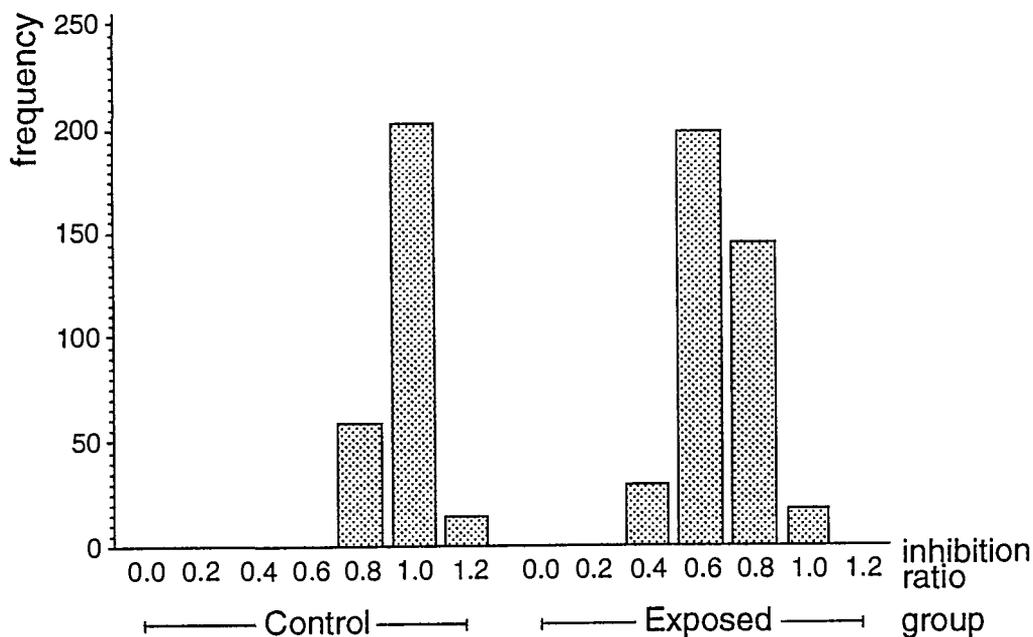
These observations were confirmed in a regression analysis of acetylcholinesterase inhibition on study area. No distinction was made between the study areas in the control group because the differences in acetylcholinesterase levels were not statistically significant ( $p > 0.10$ ). Gender and age did not contribute to the model. The exposed in area 1 had the largest inhibition (36%) followed by area 3 (35%) and area 2 (33%). Area 4 had, by far, the least inhibition (26%) (Table 3.5).

**Table 3.5** Regression analysis of acetylcholinesterase inhibition on study area in 666 individuals\*

Study area	coefficient <sup>#</sup>	Standard Error	(t-test)
Intercept(Controls)	0.96	0.060	0.0001
Naivasha	-0.32	0.010	0.0001
Wundanyi	-0.29	0.012	0.0001
Homabay	-0.31	0.017	0.0001
Migori	-0.22	0.013	0.0001

\*Acetylcholinesterase inhibition uncorrected for haemoglobin.  $R^2 = 0.66$

<sup>#</sup>parameter estimate

**Figure 3.1** Distribution of cholinesterase inhibition for exposed and controls

## Discussion and conclusions

The study shows that Kenyan agricultural workers experienced inhibition of cholinesterase activity as a result of occupational exposures to organophosphate and carbamate pesticides. Dramatic reductions of acetylcholinesterase activity during the exposure period resulted in about 30% of exposed individuals with cholinesterase inhibition below 60% of their baseline levels. Infact, regardless of the criterion used (60% or 70% of baseline), this study has shown that many of the exposed individuals experienced inhibition of acetylcholinesterase activity at levels that could result in clinical and subclinical health effects.

Acetylcholinesterase inhibition was found to be independent of gender and age but not of study area. This finding confirms observations by Coye et al (1986) who reported that cholinesterase activity does not change with age in adults and further that there is no difference in red blood cell enzymatic activity associated with sex and race. Workers in area 1, on large commercial farms, utilizing many different organophosphate and carbamate pesticides almost throughout the year had the largest cholinesterase inhibition. Pressure to produce a perfect crop without pest damage for export to Europe may have contributed to this extensive use of pesticides. Several pesticide applicators on these farms, sprayed crops at the same time, in the same plot, sometimes, spraying pesticides onto each other. The spraying methods used on these farms such as boomsprayers, underground pump-jets, as well as high pressure hose-spraying, may be responsible for the increased exposure and, therefore, the greater inhibition in area 1. Furthermore, these large-scale commercial farms were able to afford the more toxic and potent organophosphate and carbamate pesticides (Class Ia, Ib and II) but did not always provide the workers with the required supervision or all the necessary protective gear, especially respirators. Even when personal protective devices were provided, some workers did not wear them because they were cumbersome and uncomfortable. The worker's clothing and overalls were usually made of cotton which soaked up pesticides easily, possibly increasing dermal exposures.

The percentage of exposed workers with acetylcholinesterase activity at or below 60% of the red blood cell baseline (30%) was higher than those found by other researchers such

as Ames et al (1989a, 1989b) (4.8%, n=542). The most likely explanation for this was that our workers had less protective gear and used different spraying techniques and personal hygiene practices compared with the Californian workers. Furthermore, Ames et al. (1989a, 1989b) studied a group of workers who were already subject to regulations requiring engineering controls, industrial hygiene measures and medical supervision. In addition, our agricultural workers especially those from the flower growing area, were exposed to many different types of organophosphate and carbamate pesticides (Class I and II), sometimes simultaneously, for long periods at a time often without adequate supervision.

Quinones et al (1976) found significantly depressed acetylcholinesterase activities in the migrant farm workers studied in New Jersey. About 10.5% (n = 57) of these workers had values below the lower limit of normal. This value is also lower than what we found and may be attributable to the better working conditions usually prevailing in developed countries as opposed to developing countries such as Kenya. Rama and Jaga (1992) conducted a preliminary survey to establish the extent of pesticide exposure in a farming community in a coffee plantation in the Northern Region of South Africa. They found that 77% (n = 69) of their exposed subjects had acetylcholinesterase levels below the normal reference range, a much worse situation than we found in Kenya.

In area 4, where the exposed individuals showed the least acetylcholinesterase inhibition, pesticide use was limited. A company that provided farm inputs on loan to these tobacco farmers controlled the type and quantity of pesticides used in this area. The periods of spraying were also limited and were sometimes supervised by agricultural personnel from the same company. Although the farm workers in area 4 were less protected, with regard to personal protective devices, than the workers in area 1, they were subject to less inhibition of Acetylcholinesterase.

### ***Methodological Assessment***

The field spectrophotometric method used, based upon the Ellman spectrophotometric method was relatively simple to use and it was possible to teach it to people with limited technical background, compared with laboratory methods such as the electrometric,

colorimetric, titrimetric and tintometric methods used in laboratory determination of acetylcholinesterase (Coye et al., 1986). This method precluded the need for transport and storage of samples, temperature control and problems of reagent preparation and storage. The method was quite precise, with good reproducibility, and so baseline data could be compared with later values for the same subject.

In this study, erythrocyte cholinesterase values were determined because it has been reported that erythrocyte rather than plasma values are recommended as the end point; the former better reflects physiological effects on the nervous system (Coye et al., 1986). Acetylcholinesterase is also less affected by other health conditions than plasma cholinesterase, which is influenced by numerous factors other than pesticide exposure, including the general level of nutrition, liver damage, the use of foods containing xanthine (coffee, tea) and the use of drugs such as morphine, codeine chloroquine and thiamine (Ames et al., 1989a, 1989b; Wills, 1972). We also obtained a baseline measurement because Ames et al. (1989a, 1989b) have reported that in the absence of baseline cholinesterase measurements, interpretation of reported cholinesterase activity is difficult. In addition, we corrected for haemoglobin because Coye et al. (1986) have indicated that erythrocyte cholinesterase activity, which is measured per unit volume of whole blood, may be decreased in the presence of anaemia, if the measurement is not corrected for the haematocrit (haemoglobin). Our results, however, did not show such an effect.

### *Limitations of the study*

For reasons related to cultural beliefs, it was sometimes difficult to obtain and maintain consent from the study subjects when invasive procedures were to be used especially when these included the removal of blood. The level of dropouts did not affect the study as the people who remained in the study had the same characteristics as those who dropped out. There was, therefore, no selection bias and the numbers that remained were adequate for purposes of the study. Because many pesticides were sometimes used at the same time (cocktails), it was not possible for us to determine the particular pesticides responsible for cholinesterase inhibition and the cocktails may have had synergistic effects, probably lowering the cholinesterase levels still further.

The study focused mainly on the exposure to pesticides of applicators. Re-entry activities may, however, also result in exposure to pesticides. Pruners, supervisors and harvesters, especially in the flower-growing area, were allowed, without protective gear, into the fields during or immediately after spraying. This group at risk, including graders, pregnant women and children carried on the backs of female workers, was not studied.

## **Conclusions**

The dramatic acetylcholinesterase inhibition observed could lead to chronic clinical and subclinical intoxication. These findings show that acetylcholinesterase inhibition can be used as an indicator of organophosphate and carbamate poisoning in occupationally exposed agricultural workers. It also shows that agricultural workers in Kenya are exposed to cholinesterase inhibiting pesticides. This could lead to adverse health effects. There is, therefore, an urgent need for primary prevention programs to monitor and to address occupational exposures to these hazardous substances in agriculture in Kenya and other developing countries, as well as encourage the use of integrated pest management strategies in crop protection.

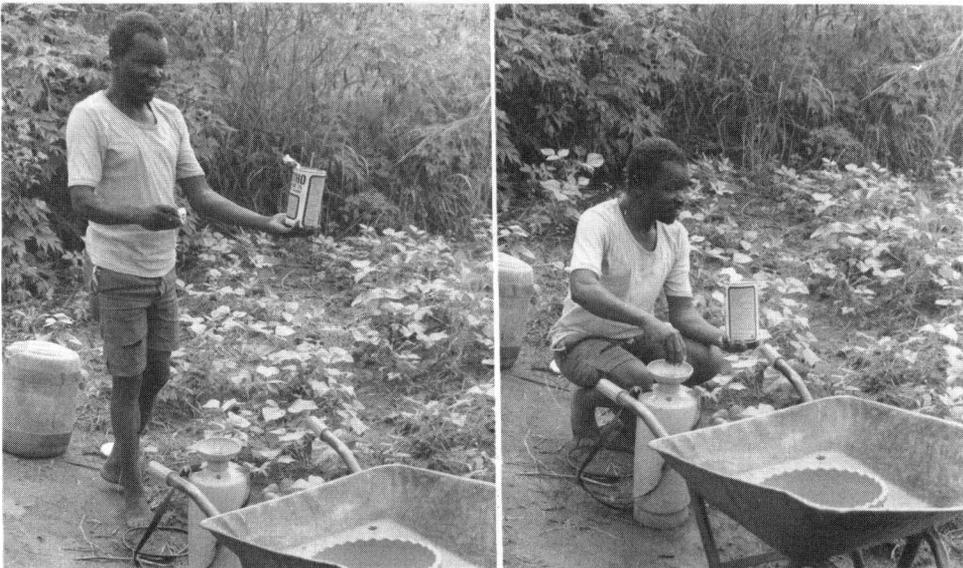


## Chapter 4

# Identification of determinants of pesticide exposure among Kenyan agricultural workers using empirical modelling

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## Abstract

Empirical modelling techniques were used to identify and quantify factors affecting exposure to organophosphate and carbamate pesticides, measured as acetylcholinesterase activity levels in red blood cells (RBC) among agricultural workers in Kenya. In an earlier part of the study, dramatic shifts in acetylcholinesterase activity were observed between periods in which pesticides were sprayed and background levels assessed during periods with (hardly) no exposure to these pesticides. The study was performed in four areas showing different shifts in acetylcholinesterase activity, which might be contributed to different crops sprayed, different application techniques, differences in personal hygiene practices (hygienic behaviour) and access and use of personal protective devices and of course different types of pesticides used. The objective of this chapter was to estimate the influence of factors such as, type of pesticides used, use of personal protective devices (ppd) and personal hygiene practices (hygienic behaviour). The models were adequate as they explained 57-70% of the observed variability in acetylcholinesterase. Results show that there were considerable differences in possible determinants of cholinesterase inhibition between areas, especially with regard to personal protective devices which were almost non-existent in areas 3 and 4. There was, however, no significant difference in hygienic behaviour between areas. WHO Class I pesticides were mostly found in area 1 which also had the highest amounts and frequency of pesticide spraying, while areas 2 and 3 used minor amounts of these pesticides. Area 3, did not use any WHO Class I pesticides at all. Despite high percentage ppd use in area 1 compared to areas 3 and 4, there was a large reduction of acetylcholinesterase from baseline values. It is not clear whether this was as a result of ppds soaking pesticide thereby increasing dermal exposure or for some other reason. The situation, however, could possibly have been much worse without any ppd at all. The models give no clarification with regard to this. In area 1, most workers wore boots, which were found to be protective only when combined with an overall; wearing of boots alone led to more inhibition. Access to a washing or bathing facility was found to have a positive effect on acetylcholinesterase levels. However, washing of hands and bathing seemed reactive rather than proactive; the workers washed and bathed immediately or during the course of a spray shift as a result of spilling accidents or other contamination. Spraying was found to have a more profound effect on cholinesterase levels than mixing. In area 1, sprayers did not perform other jobs

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and sprayed everyday for long hours, exposing themselves to more pesticide than the mixers. It has also been shown that workers who sprayed WHO Class III pesticides had less inhibition (5%), than their counterparts who sprayed more toxic pesticides. Unfortunately, hardly any variability existed in factors such as ppd and hygienic behaviour within areas and this phenomenon limited the power of the statistical models to detect the effects of these potential factors affecting exposure.

## **Introduction**

Both task-specific sampling and exposure modelling can be used to unravel factors affecting occupational exposure and consequently to develop control measures (Olsen 1994, Nicas and Spear 1993, Kromhout et al. 1994, Preller et al. 1995). In this paper we will apply empirical modelling techniques to identify and quantify factors affecting exposure to organophosphorus and carbamate pesticides measured as acetylcholinesterase activity levels in red blood cells among agricultural workers in Kenya (Ohayo et al. 1997a). In the study dramatic shifts in acetylcholinesterase activity were observed between periods in which pesticides were sprayed and background levels assessed during periods with (hardly) no exposure to these pesticides. The study was performed in four areas showing different shifts in acetylcholinesterase activity, which might be contributed to different crops sprayed, different application techniques, differences in personal hygiene practices (hygienic behaviour) and access and use of personal protective devices and of course different types of pesticides used. The objective of this part of the study was to estimate the influence of factors like type of pesticide used, use of personal protective devices and hygienic behaviour. Insight into these factors might provide ways to prevent hazardous effects of the exposures present among the agricultural workers.

## **Material and methods**

Exposure to pesticides was assessed for each participant on different days during a high exposure period (Ohayo-Mitoko et al. 1996). An appointment was made with the farm management for interviews and for collecting blood samples for the determination of acetylcholinesterase at the end of the work shift (Ohayo-Mitoko et al. 1997a..chapter 3). Each participant was also interviewed on tasks performed, pesticides sprayed, hygienic behaviour and use of personal protective devices. The total fieldwork lasted from 1993 to 1994, and for each farm the observations and measurements took one day. Details of the study design can be found in Chapter 3 (Ohayo-Mitoko et al., 1997a).

Exposure data, together with self-reported information on tasks, work methods, use of personal protective devices (ppd) and personal hygienic practices were used to derive empirical statistical models linking factors affecting acetylcholinesterase activity to actual cholinesterase levels measured in the high exposure period.

The empirical models were basically linear regression models with acetylcholinesterase activity (proportion) or level (IU) as dependent variable and tasks performed, type of pesticides used, use of ppd and hygienic behaviour as independent dummy variables (i.e. variables that take on the values 0 or 1). The general regression equations were as follows:

$$\text{'Proportion of base-line Ache'} = C + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_n x_n$$

$$\text{'Ache level during high exposure period'} = C + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_n x_n$$

In which the dependent variable is either the proportion of the base-line acetylcholinesterase activity or the actual level in IU measured in the high exposure period, the  $\beta_i$ 's, are the regression coefficients and the  $x_i$ 's, the independent variables; the intercept C represents the "background" activities not covered by the variables in the regression model.

The regression coefficients represent the contribution to the acetylcholinesterase activity level of factors such as spraying a specific pesticide or using personal protection and they reflect the difference in activity between workers who sprayed and who did not spray that particular pesticide and workers who used personal protection and who did not, respectively.

The factors at hand were originally tested in univariate models and subsequently using standard step-wise regression techniques. To enter the model, each variable had to meet a significance level of 0.50 and was kept in the model if its significance was below 0.10. Model adequacy was tested using standard regression techniques such as residual plots and outlier detection. All statistical analyses were performed with SAS/PC package (version 6.11).

## Results

More than 500 observations (539) were available from four areas. The majority of the observations were from area 1 (large farms and estates producing mainly flowers, French beans, strawberries, grapes and other horticulture crops) and from area 2 (small-scale

horticulture). Areas 3 and 4 (subsistence farmers, cotton and tobacco) had far less observations (respectively, 48 and 89, respectively). Effectively, only 424 observations (of which 173 were controls) for which information on type of pesticides sprayed (chemical name) was known, could be used.

Differences in use of pesticides, hygienic behaviour and use of personal protective devices among the exposed workers were considerable (see Table 4.1). In areas 2, 3, and 4 workers did both mixing and spraying, while only in area 1 a few workers (n=4) only mixed pesticides and the majority (65%) only sprayed. Pesticides from WHO class I were mainly used in area 1 only. In area 1 workers had more access to a facility to wash or bathe immediately after use of pesticides than in other areas. Only workers in area 2 tended to wash and bathe less and did not often change clothes immediately after use of pesticides compared to the other areas. Personal protective devices and clothing were most frequently used (available) in area 1. In contrast, within the rest of the study areas, especially areas 3 and 4, hardly any personal protective devices or clothing were used.

**Table 4.1** Distribution of factors possibly affecting exposure among exposed workers by area (%)

Factor	Area 1 n=106	Area 2 n=91	Area 3 n=24	Area 4 n=30
<b>Task</b>				
Mixing	30.2	96.7	100	100
Spraying	91.5	97.8	100	100
<b>Pesticide class (WHO)</b>				
I	16.0	2.2	0.0	3.3
II	29.3	61.5	100	70.0
III	35.9	12.1	4.2	3.3
T5	37.7	65.9	0.0	50.0
<b>Hygienic behaviour</b>				
Wash or bath immediately after work with pesticides	93.4	52.2	100	100
Access to a facility to wash or bathe	95.3	70.0	69.2	89.3
Change clothes after work with pesticides	92.5	47.8	100	83.3
<b>Personal protection</b>				
PPD	97.1	28.4	7.1	0.0
Gloves	84.9	4.5	0.0	0.0
Boots	95.3	14.4	7.1	0.0
Handkerchief	24.8	1.1	7.1	0.0
Headcover	49.1	32.2	0.0	0.0
Overall	84.8	5.6	7.1	0.0
Apron	46.9	13.5	0.0	0.0

**n=number of workers**

**Table 4.2** Statistically Significant<sup>1</sup> Factors Affecting Acetylcholinesterase Activity (proportion at base-line level) and Estimated Mean Activity (analysis with pesticide class, hygienic behaviour and use of personal protection devices; 409 observations; R<sup>2</sup>=0.70)

Factors	AM <sup>2</sup>	95% ci <sup>3</sup>
Control workers (n=173)	0.96	0.95-0.98
Workers spraying (n=236)	0.65	0.62-0.68
Workers spraying Class III pesticides (n=54)	0.70	0.66-0.74
Workers spraying with access to bath/wash facility (n=197)	0.68	0.66-0.70
Workers spraying and wearing boots only (n=26)	0.56	0.51-0.61
Workers spraying and wearing boots and overall (area 1) (n=88)	0.60	0.56-0.64

<sup>1</sup> significance level of coefficients:  $p < 0.05$ , except for wearing boots and overall:  $p < 0.07$

<sup>2</sup> estimated arithmetic mean

<sup>3</sup> ci: confidence interval

In Table 4.2 statistically significant factors affecting acetylcholinesterase activity are given. The model explained 70% of the observed variability in activity levels. Controls had a small but statistically significant reduction in baseline acetylcholinesterase activity of 4%. Workers spraying, on the other hand, had their activity decreased by 35% on average. Sprayers in areas 1 and 2 who used boots during spraying, were even more affected and showed an activity level of only 0.56. The sprayers in area 1 who wore boots and overalls were slightly less affected at 0.60. Sprayers having access to a bathing or washing facility showed significantly less inhibition at 0.68, than their counterparts without these facilities. The workers who sprayed WHO class 3 pesticides had 5% less inhibition than their colleagues spraying the more toxic pesticides (0.70 vs. 0.65).

A model with actual acetylcholinesterase level in the high exposure period as the dependent variable resulted in less explained variability (R<sup>2</sup> = 0.57 vs R<sup>2</sup> = 0.70) (Table 4.3). A rather remarkable factor showing an opposite effect from what was expected was 'washing/bathing immediately after spraying'. The coefficient indicated lower cholinesterase levels for workers who did wash and bath immediately after spraying. The most likely explanation for this phenomenon would be rather more re-active (after spills, heavy exposure, etc.) than pro-active behaviour among exposed workers.

**Table 4.3** Statistically significant<sup>1</sup> factors affecting acetylcholinesterase level (IU) and estimated mean activity (analysis with pesticide class, hygienic behaviour and use of personal protection devices; 411 observations;  $R^2=0.57$ )

Factors	AM <sup>2</sup>	95% ci <sup>3</sup>
Control workers (n=173)	5.92	5.81-6.04
Workers spraying (n=238)	4.43	4.22-4.65
Workers spraying class III pesticides (n=54)	4.71	4.41-5.01
Workers washing/bathing immediately after spraying (n=188)	4.03	3.90-4.15

<sup>1</sup> significance level of coefficients:  $p < 0.05$

<sup>2</sup> estimated arithmetic mean

<sup>3</sup> ci: confidence interval

Given the large differences in actual number and type of pesticides used from area to area (see Table 4.4), models were also elaborated for each area separately, except areas 3 and 4 that were combined due to the small number of available observations and similar type of workers (subsistence farmers).

In Table 4.5 the results for area 1 (large scale horticulture) are shown. The regression model explained 72% of the variability in Ache-activity. Workers spraying mancozeb and cyhalothrin showed significantly lower Ache-activity than workers spraying other pesticides (see Table 4.4). Workers spraying permethrin showed far less inhibition. In area 1 however, most pesticides were applied as mixtures (*cocktails*) which was not taken into account in this model. Use of personal protective clothing and other devices as well as hygienic behaviour did not show up in the models as statistically significant factors.

**Table 4.4** Pesticides use by area

Pesticide	Used (%)	Type	WHO Class
<b>Area 1</b>			
Dimethoate	7	Organophosphate	II
Benomyl	10	Carbamate	III
Mancozeb	9	Carbamate	T.5
Methomyl	22	Carbamate	IB
Aldicarb	6	Carbamate	IA
Bifenthrin	14	Pyrethroid	II
Cyhalothrin	5	Pyrethroid	II
Permethrin	2	Pyrethroid	II
Endosulfan	6	Organochlorine	I
Chlorothalonil	12	Organochlorine	T.5
Paraquat	4	Bipyridylum	II
Amitraz	10	'herbicide'	III
Propargite	8	Sulfite	III
Captan	4	phthalimide	T.5
Oxycarboxin	7	Phenylamide	T.5
<b>Area 2</b>			
Malathion	9	Organophosphate	III
Mancozeb	44	Carbamate	T.5
Propineb	29	Carbamate	T.5
Bifenthrin	13	Pyrethroid	II
Cyhalothrin	7	Pyrethroid	II
Permethrin	36	Pyrethroid	II
<b>Areas 3 and 4</b>			
Mancozeb	28	Carbamate	T.5
Permethrin	81	Pyrethroid	II
Anilazine	13	Amine	III

**Table 4.5** Statistically significant<sup>1</sup> factors affecting acetylcholinesterase activity (proportion of base-line levels) and estimated mean activity for area 1 (analysis with pesticide sprayed, hygienic behaviour and use of personal protection devices; 192 observations;  $R^2=0.72$ )

Factors	AM <sup>2</sup>	95% ci <sup>3</sup>
Control workers (n=86)	0.96	0.94-0.98
Workers not spraying or only mixing (n=9)	0.73	0.64-0.81
Workers spraying (n=97)	0.64	0.62-0.67
Workers spraying mancozeb (n=10)	0.57	0.49-0.64
Workers spraying cyhalothrin (n=5)	0.55	0.46-0.65
Workers spraying permethrin (n=2)	0.79	0.64-0.96

<sup>1</sup> significance level of coefficients:  $p < 0.05$ , except for spraying cyhalo and permethrin:  $p < 0.07$

<sup>2</sup> estimated arithmetic mean

<sup>3</sup> ci: confidence interval

For the data from area 2 (small-scale horticulture) the model explained also 72% of the variability (Table 4.6). Farmers spraying malathion, an organophosphate from WHO class III, had significantly less inhibition than workers spraying either mancozeb, bifenthrin, cyhalothrin, or permethrin. Significantly more inhibition was estimated for farmers spraying propineb, a carbamate from WHO class T.5. Other factors like use of ppd and hygienic behaviour showed no effect.

**Table 4.6** Statistically significant<sup>1</sup> factors affecting acetylcholinesterase activity (proportion of base-line level) and estimated mean activity for area 2 (analysis with pesticide sprayed, hygienic behaviour and use of personal protection devices; 161 observations;  $R^2=0.72$ )

Factors	AM <sup>2</sup>	95% ci <sup>3</sup>
Control workers (n=70)	0.96	0.94-0.98
Workers spraying (n=91)	0.67	0.65-0.69
Workers spraying malathion (n=8)	0.85	0.78-0.91
Workers spraying propineb (n=26)	0.62	0.58-0.66

<sup>1</sup> significance level of coefficients:  $p < 0.05$

<sup>2</sup> estimated arithmetic mean

<sup>3</sup> ci: confidence interval

**Table 4.7** Statistically significant<sup>1</sup> factors affecting acetylcholinesterase activity (proportion of base-line level) and estimated mean activity for areas 3 and 4 (analysis with pesticide sprayed, hygienic behaviour and use of personal protection devices; 71 observations;  $R^2=0.65$ )

Factors	AM <sup>2</sup>	95% ci <sup>3</sup>
Control workers (n=17)	0.96	0.92-1.01
Workers spraying (n=54)	0.66	0.63-0.69
Workers spraying mancozeb (n=15)	0.74	0.69-0.79

<sup>1</sup> significance level of coefficients:  $p < 0.05$

<sup>2</sup> estimated arithmetic mean

<sup>3</sup> ci: confidence interval

In the model for areas 3 and 4 (subsistence farmers) only farmworkers spraying mancozeb showed statistically significant less inhibition compared to farmworkers spraying permethrin and anilazin. Again, factors like use of ppd and hygienic behaviour were not relevant in the model. The estimated arithmetic mean acetylcholinesterase levels for sprayers of mancozeb was much higher in areas 3 and 4 than in area 1 (0.74 vs. 0.57). Possible explanations for this discrepancy might be the earlier noticed use of pesticide mixtures in area 1 and differences in actual levels of exposure.

## Discussion

Limitations of the models include the fact that we used self-reported data and did not test for reliability and validity using data from observations. In addition, there was no knowledge on real determinants as quantitative exposure assessment was not performed.

The models were adequate as they explained 57-70% of the observed variability in acetylcholinesterase levels. Results show that there were considerable differences in possible determinants of cholinesterase inhibition between areas, especially with regard to personal protective devices which were almost non-existent in areas 3 and 4. There was, however, almost no significant difference in hygienic behaviour between areas. WHO Class I pesticides were mostly found in area 1, while areas 2 and 3 used minor amounts of these pesticides. Area 3 did not use any WHO Class I pesticides at all. This may be because small scale farmers cannot afford the high cost of Class I pesticides and are not under pressure to produce a perfect crop as their products are mainly for local consumption. Furthermore, most of the farmworkers in areas 2, 3 and 4 performed both mixing and spraying tasks. In contrast, only about one third of the farmworkers in area 1 performed mixing tasks while about 65% performed spraying tasks only. Unfortunately, hardly any variability existed in factors such as ppd and hygienic behaviour within areas. This phenomenon limited the power of the statistical models to detect the effects of these potential factors affecting exposure.

Despite high percentage PPD use in area 1 compared to areas 3 and 4, there was a large reduction of acetylcholinesterase levels from baseline values. This may be possibly because ppds were either not properly used or soak pesticide during spraying leading to more dermal exposure. The situation, however, could possibly have been much worse without any ppds at all. The models give no clarification with regard to this point. In addition, in area 1 very large amounts of pesticides were used compared to the other areas. It is also the area with the largest amount of extremely hazardous pesticides (WHO class 1) and where the frequency of pesticide spraying was highest. In area 1 most farmworkers wore boots, which was found to be protective only when combined with an overall. Wearing boots solely appeared to lead to more inhibition, most likely because most clothing worn (other than overalls) were made of cotton, leading to soaking of

sprayed pesticides which consequently drained into the boots with a possibility of enhanced dermal uptake due to occlusion. Other overalls used were 'coat-like' and prevented pesticides from draining into the boots.

Access to a washing or bathing facility was found to have a positive effect on acetylcholinesterase levels. Also, farmworkers washing/bathing immediately after spraying or during the course of a spray shift, were seen to do that as a result of spilling accidents or other contamination. It has also been shown that workers who sprayed WHO class III pesticides had less inhibition (5%), than their counterparts who sprayed more toxic pesticides.

Spraying was found to have a more profound effect on cholinesterase levels than mixing. In area 1, sprayers did not perform other jobs and sprayed everyday for long hours, exposing them to more pesticide than mixers. For all the other areas, spraying and mixing was done by one and the same person.

The models for the individual areas showed conflicting results which could not be explained. For instance for the pesticide mancozeb used in all areas; 0.57, 0.67 and 0.74 was estimated by the models for areas 1, 2, and 3 and 4 combined, respectively. Differences in application technique, actual exposure and the earlier mentioned application of cocktails might explain these conflicting results. In none of the area-specific models did use of ppd or hygienic behaviour show up as an important factor. Lack of variation in these factors within an area is the most likely explanation.

## Conclusion

Although the models explained a relatively large part of the variability in acetylcholinesterase activity, only few factors showed up as important determinants of exposure. Lack of variation within an area and too large differences between areas (crops, pesticides used, etc.) prevented this. Nevertheless, spraying less toxic pesticides (WHO class III), wearing adequate ppd and having access to a bathing and washing facility seemed to prevent severe inhibition (>30% inhibition; < 70% of baseline level). More drastic measures are, however, needed to prevent cholinesterase inhibition among these farmworkers and farmers.

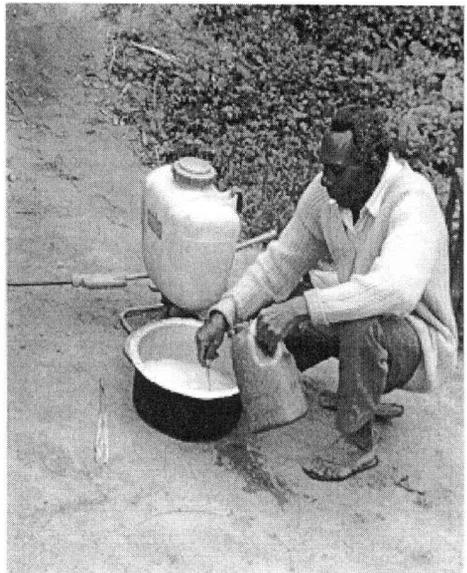
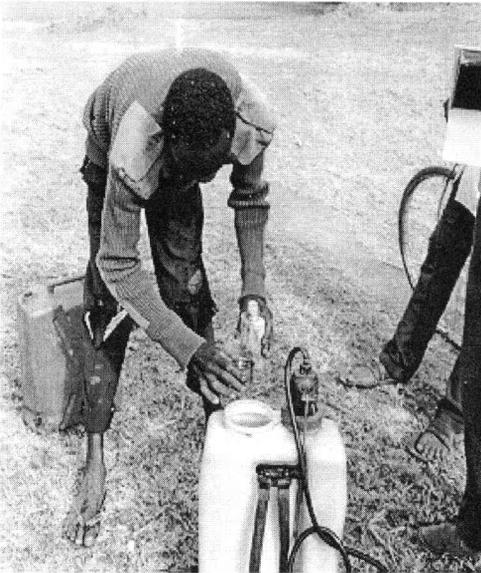


## Chapter 5

### Self-reported symptoms and acetylcholinesterase inhibition among Kenyan agricultural workers

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## Abstract

Cholinesterase monitoring is intended to prevent further exposure of asymptomatic workers with depressed cholinesterase activity levels, thereby preventing poisoning. While the effects of acute pesticide poisoning are well known, hardly any data exist with regard to chronic effects. We recently reported on acetylcholinesterase as an indicator of organophosphate and carbamate exposure in Kenyan agricultural workers. Among the exposed individuals, 29.6% had their cholinesterase levels depressed to values below 60% of baseline levels. The aim of this paper is to describe the prevalence of symptoms in this population, to relate levels of inhibition to reported symptoms and to evaluate at which inhibition levels symptoms become elevated. Complete data to study the relationship between cholinesterase inhibition and self-reported symptoms (health complaints) were available for only 256 exposed subjects (41.1%) and 152 controls (29.5%). Information was obtained on the gender of the worker, age, main occupation and level of education. Additional questions were asked on symptoms experienced at the time of interview, with a checklist of 42 symptoms. The results of a factor analysis *a posteriori* confirmed the existence of several clusters of symptoms identified *a priori*. The following clusters were obtained for further analysis; skin/extremities, respiratory, systemic, eye and central nervous system (CNS) symptoms. Of the symptoms in the cluster, a positive score on two or more was used as a cut-off point for further analysis, depending on the number of complaints in a cluster. The prevalence of symptoms was higher during the high exposure period than during the low exposure period in exposed subjects, although these differences were statistically non-significant. Interestingly, a clear and statistically significant change in symptoms prevalence was observed in the controls (Chi-square;  $p < 0.05$ ). The presence of a relationship between acetylcholinesterase inhibition, acetylcholinesterase level and respiratory, eye and CNS symptoms was established. Increased symptom prevalence was observed at acetylcholinesterase levels which are generally considered as non-adverse. This relationship requires confirmation in an independent study using more objective health parameters such as medical examinations and neurobehavioural batteries.

## Introduction

Cholinesterase monitoring is intended to prevent further exposure of asymptomatic workers with depressed cholinesterase activity levels, thereby preventing poisoning (Brown et al, 1989; Lopez-Carillo and Lopez Cervantes, 1993; Lessenger, 1995). Organophosphate and N-methyl carbamate pesticides inhibit cholinesterase, which results in an accumulation of acetylcholine in the nervous system. Cholinesterase activity depressions to 60% of baseline can produce relatively mild and non-specific symptoms such as vertigo, nausea, anxiety, vomiting, diarrhoea, asthma-like tightness of the chest, increased sweating, increased salivation, wheezing and shortness of breath increased tearing, constriction of the pupils and malaise (Ames et al. 1989a, 1989b; Markowitz, 1992; Padilla, 1995; Lotti, 1995). Severe poisoning resulting in greater depression of cholinesterase activity may result in unconsciousness, pulmonary oedema, respiratory failure and death (Namba et. al, 1971; Khan, 1976; Hayes, 1982; Kalayanova, 1982; Coye et al., 1987; Ames et al., 1989a, 1989b). Effects on the gastro-intestinal system and bradycardia have also been associated with poisoning by cholinesterase-inhibiting pesticides (Kashyap et. al., 1984). Depressions resulting from organophosphate exposures can be cumulative, whereas depressions resulting from carbamate exposures are usually rapidly reversed (Gage, 1967; Vandekar and Plestina, 1971).

While the effects of acute pesticide poisoning are well known, hardly any data exist with regard to chronic effects, particularly neurotoxic and behavioural aspects of organophosphate exposures (Davies, 1990; Forget, 1991; Robinson et al., 1993; Kishi et al., 1996 ). Clusters of neurologic, rather than behavioural diseases were the earliest sequelae noted following organophosphate exposures (Xintaras et al., 1978). Organophosphate-induced delayed neuropathy has been observed by Senanayake and Karaliedde (1978). Respiratory paralysis followed the cholinergic phase of the illness in cases of poisoning with methamidophos and fenthion. Also weakness was noted in proximal limb muscles and muscles of the neck. Thompson and Stocks (1997) have demonstrated the benefit of early otolaryngological consultation for the prevention and treatment of airway obstruction in patients with suspected organophosphate poisoning which can sometimes cause variant toxicity syndrome involving transient bilateral vocal cord paralysis.

De Bleeker et al. (1993), observed that intermediate and delayed neurological effects (Intermediate syndrome) coincide with prolonged cholinesterase inhibition, and is not due to muscle fibre necrosis. When viewed together, the clinical and electromyographic features are best explained by combined pre- and postsynaptic dysfunction of neuromuscular transmission. The intermediate syndrome is not related to an incipient delayed neuropathy (De Bleeker et al., 1993). Subtle behavioural changes have also been noted in several cross-sectional epidemiological studies among pest workers, and behavioural impairments have also been associated with pesticide exposure in serious accidents among agricultural workers (Maizlish et al., 1987; Eskenazi and Maizlish, 1988).

Massive literature exists on organophosphate/carbamate exposure and cholinesterase inhibition from several types of studies such as case series (Davies, 1990; Lander and Lings, 1991, Maroni et al., 1986; Coye et al., 1986) and individual case descriptions (Lessenger et al., 1995) as well as surveys (Brown et al, 1989). However, the relationships between exposure, inhibition and symptoms are not well established on the population level. The available evidence (Ames, 1989a, 1989b; Popendorf, 1990) suggests that there is a high probability of development of symptoms or even adverse side-effects below inhibition levels that are generally considered as safe (Mullie et al., 1997).

In Chapter 4, we reported on acetylcholinesterase as an indicator of organophosphate and carbamate exposure in Kenyan agricultural workers. Among the exposed individuals, 29.6% had their cholinesterase levels depressed to values below 60% of baseline levels (Ohayo-Mitoko et al., 1997a). A dramatic shift in acetylcholinesterase levels was apparent from low to high exposure period. The aim of this paper is to describe the prevalence of symptoms in this population, to relate levels of inhibition to reported symptoms and to evaluate at which inhibition levels symptoms become elevated.

## **Study design, materials and methods**

### *Sampling of farms and estates*

Selection of farms and estates was by multi-stage cluster sampling described in Chapter 3.

### *Study group*

The exposed group consisted of 623 agricultural workers, mainly applicators during the pesticide application periods, were initially recruited into the study. The follow-up rate was 62.6% (n=390). For only 256 exposed subjects (41.1%), complete data were available to study the relationship between cholinesterase inhibition and self-reported symptoms (health complaints). This is because some individuals interviews for symptoms done but did not allow blood to be removed for cholinesterase determinations. Others dropped out after the low exposure period because of illness while some were laid-off from their jobs. The control group consisted of 515 unexposed agricultural workers. These were sisal workers or subsistence farmers who were not occupationally exposed to pesticides. This group was as comparable to the exposed group as possible, in terms of occupation, nutritional and socio-economic status. The follow-up rate was 53.6% (n=276). Complete data were available for only 152 controls (29.5%).

### *Questionnaire*

A structured questionnaire in English was administered by the investigators to all subjects and controls. They were sometimes translated orally into other languages by the interviewers as the questions were asked. The questionnaire consisted of both open and closed questions. Information was obtained on the gender of the worker, age, main occupation and level of education. Additional questions were asked on symptoms experienced at the time of interview, with a checklist of 42 symptoms. Further questions were asked on whether or not some of these symptoms became more severe or frequent while working with pesticides or soon afterwards. In addition, questions were asked on how long the last pesticide symptoms lasted and whether or not the respondents had symptoms that they thought might be due to pesticide poisoning and whether or not these occurred during or after the use of pesticides. Respondents were asked if they had ever had pesticide poisoning and if so, the number of times that it had occurred and the details of the last episode, including the pesticide responsible for the poisoning episode by chemical group, chemical name, trade name and the number of days the symptoms lasted.

### ***Clustering of symptoms***

A factor analysis was conducted using the symptoms reported during the high exposure period, to verify the existence of clusters that were identified *a priori* using reference literature on health effects from cholinesterase-inhibiting (organophosphate and carbamate) pesticides. This approach was used as a tool to support data reduction strategies. Screen plots of eigenvalues showed which factor could be retained (initial factors) on the basis of statistical criteria. For better interpretation of the initial factors an orthogonal rotation by the varimax method was carried out and a rotated factor pattern was produced. A principal component model was applied to calculate factor loadings as a measure of the correlation between an individual variable and the factor. Factor loadings were examined and variables with a low loading for any of the factors were excluded. A principal component model was applied to calculate factor loadings as a measure of the correlation between an individual variable and the factor. Based on the results of the factor analysis and *a priori* derived information, symptom clusters were formed for further analysis. Each observation received a dichotomous score for each symptom cluster. Cut-off points for each symptom cluster were chosen in such a way that approximately 15-20% of the respondents had a positive score for the newly created variable.

### ***Cut-off points for acetylcholinesterase and inhibition during high exposure:***

Normal levels for acetylcholinesterase inhibition were defined using the 50th percentile (median) for inhibition in controls (5.05%) as the lowest point below which there is almost no inhibition ( $< 5.05$ ). Medium inhibition was defined as that between the median of inhibition for the controls and the WHO (1972) threshold level (acetylcholinesterase activity at 70% of baseline; 30% inhibition). The high inhibition group was that with cholinesterase inhibitions of 30% or more ( $\geq 30\%$ ).

For definition of normal acetylcholinesterase levels during high exposure, also the 50th percentile of the acetylcholinesterase distribution of the controls was used ( $> 5.95$  IU). Low level acetylcholinesterase was defined as less than or equal to the 50th percentile of the distribution of cholinesterase among the exposed during the high exposure period ( $\leq 3.95$  IU). The medium acetylcholinesterase level was defined to be between the two median values described above ( $> 3.94 \leq 5.95$  IU).

**Data analysis:** All analysis were done with SAS (Version 6.11). Associations between acetylcholinesterase inhibition and reported symptoms (complaints) were evaluated by calculating Prevalence Rate Ratios (Lee and Chia, 1993) using Cox's proportional hazards model (PROC PHREG).

## Results

Table 5.1 gives the general characteristics of the study population. Exposed workers were somewhat younger than controls and had received more education.

The main occupation of the subjects was farmers (39.3%) and knapsack sprayers (54.8%). Only 7.1% of the subjects reported that they had definitely had pesticide poisoning in the past while 40.1% reported having experienced symptoms due to pesticide poisoning, with only 25.4% seeking treatment. 9.1% of the subjects reported that the symptoms occurred during pesticide use, 27.4% after use while 7.9% reported having symptoms both during and after the use of pesticides. 22.2% of the subjects reported that they knew pesticide poisoning among the family and neighbours.

91.7% of the subjects indicated that the nature of their work with pesticides is as sprayers. 74.2% of the subjects reported that they took some precautions when working with pesticides, while 92.1% indicated that they washed or bathed immediately after the use of pesticides with 84.5% reporting that they had a facility to wash/bathe. 89.7% of the subjects reported that they usually changed their clothes right after work. Although 46.4% of the subjects reported that they normally determine the dose of pesticide to be used, more than half of the workers, especially from large-scale farms, indicated that the foreman usually decided on the type of pesticide to be used. About 71.4% reported that they stored pesticides. 87.3% of the subjects reported that their suppliers gave instructions on safe use of pesticides.

The results of the factor analysis *a posteriori* confirmed the existence of several of the clusters identified *a priori*. Especially respiratory symptoms, central nervous system (CNS) symptoms, skin symptoms and symptoms of the extremities appeared to be clearly clustered. The factor loadings of the individual variables with the subsequent cluster were

generally higher than 0.30 apart from a single exception (chest pain 0.10, loss of consciousness 0.22) and ranged up to 0.81 (wheezing). For some individual symptoms low factor loading were observed, but they were nevertheless included because of the good interpretability of the factor. A model with 9 clusters seemed optimal and explained 0.57 of the total variance. In this analysis, some symptom clusters which had been clustered *a priori* in one cluster, spread out over two or more clusters in the factor analysis. In those cases the *a priori* chosen cluster appeared to be the second best which was interpreted as supportive of the *a priori* made clustering. Some of the clusters obtained from the factor analysis were therefore combined. This resulted in five different symptom clusters which were used in the further analyses.

Self-reported symptoms...**Table 5.1** General Characteristics of the Study Population and Acetylcholinesterase inhibition and level during the high exposure period

	Age (mean $\pm$ SD)		Education					inhibition level	ache activity
	male	Female	no education	Elementary	Secondary				
Subjects	34.0 $\pm$ 13.1 (n = 245)	38.7 $\pm$ 8.0 (n = 11)	0.4	63.9	29.7		0.65 $\pm$ 0.12	4.17 $\pm$ 0.82	
Controls	37.2 $\pm$ 13.0 (n = 119)	43.0 $\pm$ 12.6 (n = 33)	16.9	59.6	23.5		0.96 $\pm$ 0.08	6.02 $\pm$ 0.64	

The following clusters were obtained for further analysis. The first group comprised symptoms of the skin and extremities which includes skin rash, itching, burning or prickling of the skin, tingling or numbness of hands, tingling and numbness of face, muscular twitching or cramps in the face, muscular twitching and cramps around the neck, muscular twitching and cramps in arms, muscular twitching and cramps in legs. Of the eight symptoms in the cluster, a positive score on three or more was used as a cut-off point for further analysis. Respiratory symptoms consist of chestpain, cough, running nose, wheezing, difficulties in breathing, shortness of breath and irritation of the throat ( $\geq 3$  out of 7) while systemic effects symptoms include excessive sweating, nausea, vomiting, diarrhoea, excessive salivation, abdominal pain, burning on urination, poor appetite ( $\geq 3$  out of 8). Eye symptoms are lacrimation and irritation of the eyes (2 out of 2) while Central Nervous System (CNS) symptoms consist of difficulty in seeing, restlessness, difficulty in falling asleep; lacrimation, irritation of the eyes, trembling of hands, irritability ( $\geq 5$  out of 14). Fever and gastro-intestinal complaints were left out as they are *a priori* not expected to be related to acetylcholinesterase inhibition. The symptoms reported during the low exposure period were less clearly clustered as were the symptoms reported during the high exposure period. This was especially true for symptoms of the skin and extremities and CNS symptoms.

The prevalence of clusters of symptoms were higher during the high exposure period than during the low exposure period in exposed subjects, except for skin extremities (Table 5.2), although these differences were statistically non-significant. Interestingly, a clear and statistically significant change in symptoms prevalence was observed among the controls (Chi-square;  $p < 0.05$ ). The symptom prevalence was higher during the low exposure period. For respiratory symptoms the difference between the two periods could be explained by a change in prevalence for shortness of breath, difficulties with breathing, wheezing and runny nose and cough. The reduction in prevalence for CNS symptoms in the high exposure period could be explained by the change in prevalence for trembling of hands, irritability, forgetfulness, restlessness, and difficulties falling asleep.

**Table 5.2** Prevalence of clusters of symptoms in the high and low exposure period respectively for both exposed (n=259) and control subjects (n=149).

Symptom		High exposure period	Low exposure period
Skin/Extremities ( $\geq 3/8$ )	exposed	12.4%	14.3%
	control	10.1%	11.4%
Respiratory ( $\geq 3/7$ )	exposed	19.3%	14.7%
	control	5.4%	14.8%
Systemic ( $\geq 3/8$ )	exposed	15.1%	12.4%
	control	8.1%	11.4%
Eye ( $\geq 2/2$ )	exposed	10.0%	5.0%
	control	4.7%	7.4%
CNS ( $\geq 5/14$ )	exposed	19.7%	17.4%
	control	8.7%	17.4%

Of all 408 individuals 155 (38.0%) had a change in acetylcholinesterase inhibition of 30% or more, 175 (42.9%) had an intermediate inhibition (between median of inhibition for the controls and activity at 70% of baseline; 30% inhibition) while 78 (19.1%) had no inhibition. 76 individuals (18.6%) had a normal acetylcholinesterase level during high exposure, 131 (32.1%) had a low acetylcholinesterase level and 201 (49.3%) had an intermediate acetylcholinesterase level. Most individuals with intermediate or strong acetylcholinesterase inhibition, respectively intermediate or low acetylcholinesterase level, were exposed to cholinesterase inhibiting pesticides during the high exposure period.

Analysis of the relationship between inhibition and symptoms showed that prevalence ratios were significantly higher than 1 for clustered respiratory and CNS symptoms for workers with more than 30% inhibition (Table 5.3).

**Table 5.3** Prevalence ratios for clusters of symptoms at day of interview by exposure group defined by acetylcholinesterase inhibition adjusted for sex and age (n=408).

Symptom	No inhibition ( $< 5.05\%$ ) (n=78)	Medium inhibition ( $\geq 5.05\% < 30\%$ ) (n=175)	High inhibition ( $\geq 30\%$ ) (n=155)
Skin/Extremities ( $\geq 3/8$ )	1	0.82 (0.35-1.94)	1.78 (0.78-4.08)
Respiratory ( $\geq 3/7$ )	1	2.04 (0.78-5.38)	2.92 (1.12-7.61)
Systemic ( $\geq 3/8$ )	1	1.20 (0.50-2.85)	1.94 (0.82-4.59)
Eye ( $\geq 2/2$ )	1	0.89 (0.27-2.94)	2.92 (0.97-1.03)
CNS ( $\geq 5/14$ )	1	2.56 (0.99-6.62)	3.29 (1.26-8.60)

These PRR ratios were corrected for age and sex. Uncorrected PRRs were generally somewhat lower. Prevalence rates for individuals with intermediate inhibition were elevated for these clusters as well, but did not reach statistical significance.

Respiratory and CNS symptoms were strongly related to acetylcholinesterase level during the high exposure period. In addition, individuals with intermediate acetylcholinesterase levels had a statistically significantly elevated symptom prevalence for these symptom categories (Table 5.4). Symptoms of the skin and extremities, systemic symptoms and eye symptoms were elevated but the Prevalence Rate Ratios did not reach statistical significance.

An internal analysis using only exposed subjects showed that only for eye symptoms a statistically significantly elevated PRR was observed using 30% inhibition and 5 IU for acetylcholinesterase level as cut-off points. Interestingly, symptoms reported during the low exposure period were not related to acetylcholinesterase level during the low exposure period.

**Table 5.4** Prevalence ratios for clusters of symptoms at day of interview by exposure group defined by acetylcholinesterase level during high exposure adjusted for sex and age (n=408).

Symptom	Normal level (> 5.95 IU) (n=76)	Medium level (> 3.95 ≤ 5.95 IU) (n=201)	Low level (≤ 3.95 IU) (n=131)
Skin/Extremities (≥ 3/8)	1	1.77 (0.71-4.41)	1.98 (0.76-5.16)
Respiratory (≥ 3/7)	1	4.10 (1.24-13.5)	4.17 (1.23-14.1)
Systemic (≥ 3/8)	1	1.51 (0.64-3.55)	1.78 (0.73-4.35)
Eye (≥ 2/2)	1	0.94 (0.32-2.72)	1.93 (0.69-5.42)
CNS (≥ 5/14)	1	2.47 (1.02-5.95)	2.54 (1.01-6.36)

## Discussion

Results from this study show that a considerable number of Kenyan agricultural workers have strong acetylcholinesterase inhibition and low acetylcholinesterase levels due to exposure to pesticides during the high exposure period. This study also shows that relationships exist between cholinesterase inhibition and symptoms, especially respiratory symptoms, central nervous system (CNS) symptoms (analyses including controls) and eye symptoms (internal analysis). This interpretation of these relationships, however, is not unequivocal and is complicated by some methodological inadequacies in the study.

The change in symptoms prevalence in controls from the high to the low exposure period is a key factor in explaining the relationships between acetylcholinesterase inhibition and acetylcholinesterase level. The internal analysis (controls excluded) yielded a statistically significant relationships of acetylcholinesterase inhibition and acetylcholinesterase level with eye symptoms. In addition, the analysis including controls showed strong relationships between acetylcholinesterase inhibition and acetylcholinesterase level and CNS and respiratory symptoms. However, the symptom prevalence during the high exposure period was low in controls compared to the same controls in the low exposure period. This introduced a statistically significant difference in symptom prevalence between exposed workers and controls during the high exposure period while the symptom prevalence did

not differ between these two groups during the low exposure periods.

It could be argued that the elevated prevalence for some symptoms in both exposed and controls during the low exposure period is caused by external non occupational factors such a climate (temperature and humidity), and environmental dust exposure. The weaker clustering of these symptoms and the absence of a relationship between symptoms and acetylcholinesterase level for the low exposure period supports this explanation. The low exposure period occurs during the hot and dry season of the year. During this period fields and roads are dry and dust is suspended in the air by the wind. The high dust levels might explain some of the respiratory symptoms. The high prevalence of symptoms like irritability, forgetfulness, restlessness, and difficulties falling asleep could be explained by the high temperature during this period. Symptoms in controls due to the high temperatures and environmental dust disappear during the high exposure period but remain in exposed workers because of organophosphate/carbamate exposure. This explanation is also supported by the observation that acetylcholinesterase inhibition and acetylcholinesterase level are normal in controls during the high and low exposure period but change considerably over time in exposed workers (Chapter 3).

The present study also suggests that an increased symptom prevalence might also occur at acetylcholinesterase levels that are generally considered as non-adverse (less than 30% inhibition). However, because of the above mentioned methodological problems this observation needs support by additional evidence from another independent study that included objective health parameters such a spirometric measurements, nerve conduction parameters and neurobehavioural test batteries like the NES (Spurgeon et al., 1996).

We evaluated the potential influence of different forms of bias. It is unlikely that selection bias might explain the outcomes of this study. The sample used for this study (n=408) has a similar age distribution as the original (source) population of 666 individuals (Ohayo-Mitoko et al., 1997a). Most of the data were self-reported, which could introduce a strong information (responder) bias if the facts had been distorted by persons involved, including employers, either in hope of secondary gain or to avoid adverse outcomes, such

as being fired or investigated by the authorities. Some of the subjects consisted of groups from large farms and their input could reflect a psychogenic group consensus rather than the individual's unbiased assessment. Although independent information on the validity of the questionnaire items is not available, it seems unlikely that responder bias can explain the differences in symptom prevalence between exposed and control workers and the relationships between acetylcholinesterase inhibition and acetylcholinesterase level and symptoms. The relationships between symptoms and potential confounders such as age and gender had the expected directions (increased prevalence for women and increasing prevalence with increasing age) and these relationships would also have been distorted when considerable responder bias would have been present. It is also possible that some of the relationships might have been confounded by the effects of smoking. Information on smoking habits was not available for both controls and exposed workers and correction for differences in smoking habits between exposed workers and controls was therefore not possible. This could especially have affected the relationships observed for respiratory symptoms. However, it is unlikely that differences in smoking habits can account for the large differences in respiratory symptom prevalence between controls and exposed during the high exposure period. Controls came from the same area as the exposed workers. The age distributions were similar as was the SES (measured as educational level). This makes the existence of large differences in smoking habits unlikely.

In conclusion, results of this study suggest the presence of a relationship between exposure to acetylcholinesterase inhibition, acetylcholinesterase level and respiratory, eye and CNS symptoms. Increased symptom prevalence was observed at acetylcholinesterase levels which are generally considered as non-adverse. This indicates the need for more health-protective threshold levels that are more sensitive than the WHO recommended threshold at 70% of baseline red blood cell cholinesterase activity (30% inhibition). However, the relationship above requires confirmation in an independent study using more objective health parameters and neurobehavioural batteries (Spurgeon, 1996).



## **PART III**

# **SOCIAL CONSIDERATIONS AND IMPLICATIONS FOR HEALTH PROMOTION INTERVENTIONS**



## Chapter 6

# Patterns of pesticide handling and use, knowledge and reported practices of Kenyan agricultural workers

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*Submitted to Health Promotion International*



## Abstract

The objective of the reported study was to assess the knowledge, observed and reported practices of Kenyan Agricultural Workers, with respect to safe handling and use of pesticides. A structured questionnaire was administered to 390 agricultural workers, males (92.8%) and females (8.2%), from the study areas within Naivasha, Wundanyi, Homabay and Migori districts of Kenya, consisting mainly of sprayers, farmers, tractor drivers and supervisors. Results indicate that the knowledge of the agricultural workers with regard to safe use of pesticides was very low. Two-thirds of the respondents did not know the most important route for pesticide poisoning in occupational exposure. About three-quarters of the respondents reported that they stored pesticides, with more than half not storing pesticides and equipment in a pesticides store but in places like, "under the bed", in the bush or in the latrine. About 95% of the farms did not have an inventory of pesticide supplies in the store. Most of the pesticides in storage on the farms were in their original containers, labelled and with mixing instructions and the containers were closed tightly. There was almost no danger of fire or explosion on the farms visited as a result of pesticide storage. About half of the "stores" were dry, well-ventilated, protected from sunlight and heat while only one third were locked-up and only 7.5% had doors labelled for caution. The decisions on the types and dosages of pesticides used were mostly made by the supervisors/farm owners in Naivasha and slightly over half by the tobacco company in Migori. In Wundanyi and Homabay, most of these decisions were made by the farmers and their families. There was possibility of contamination of water sources in 26% of the farms, especially during mixing and spraying. Over 90% of the spraying equipment were knapsacks and most of the mixing was done either in the knapsacks or in the tanks for boomsprayers or hose-sprayers. Naivasha reported the highest number of agricultural workers who took precautions and wore personal protective devices when working with pesticides, and had more often a better combination of personal protective devices, followed by Wundanyi and Homabay. None of the agricultural workers in Migori wore personal protective devices when working with pesticides. Most of the workers interviewed had a facility to wash or bathe after the use of pesticides. While farmworkers employed by others scored the highest with regard to personal protective devices and personal hygiene, those employed by tenant farmers scored the lowest.

The results show that there is an urgent need to implement training programmes to improve the knowledge, perceptions and practices of agricultural workers in Kenya with regard to safe use of pesticides.

## Introduction

Synthetic pesticides have been used intensively for crop protection in many countries since the end of the Second World War. At present, nearly 85% of world pesticide production is consumed in the industrialized countries. Yet the incidence of pesticide poisoning is thirteen times higher in developing countries. Epidemiological studies have shown that farm workers are the group hardest hit by accidental poisoning (Forget, 1989), and that sprayers are, often, especially at high risk because of inadequate protective clothing, drift of spray droplets, leaks in the spraying equipment, or other reasons (Zandstra, 1987).

Although Kenya's economy is dependent on agriculture, only one third of the land is arable. Unfortunately, one third of the crop yield is destroyed by pests while in the farms or stores (Mukunya, 1988). In order to overcome the pest problem, farmers have doubled the importation and use of agrochemicals in the last decade (Mwanthi and Kimani, 1993). Enormous amounts of the agrochemicals are imported and extensively used every year. Although they are intended to kill pests, these chemicals have accidentally and intentionally caused many deaths. Infact, a recent study estimated that of the five million people in the agricultural sector of Kenya, 350,000 (7 per cent) are poisoned by pesticides annually, at an annual economic impact of Kshs. 336 million (US \$11.2 million)(Choudhry and Levy, 1988). The major causes of agrochemical poisoning in Kenya and other developing countries stem from the lack of awareness of the risks of agrochemicals, illiteracy, lack of instructions on the agrochemical containers, lack of pictograms, failure to use protective clothing and re-use of the empty containers to store edibles (Mwanthi and Kimani, 1990; Zandstra, 1987; Forget, 1991).

Most epidemiological studies from developed countries have focussed on the relationship between long-term exposure to pesticides and cancer or reproductive effects (Shou-zhen, 1987). Agrochemical hazards tend to be more serious in developing countries, where their use is widespread and where pesticides banned elsewhere because of their carcinogenic, mutagenic and teratogenic effects, are still being used (WHO/UNEP, 1987). In Sri Lanka and other Asian countries such as Indonesia, Malaysia, Thailand and the Phillipines, the

majority of pesticide poisoning cases are by intentional ingestion, usually for suicidal purposes (Lum et al, 1993; Forget, 1991). Several South-East Asian countries have reported acute pesticide poisoning caused by consumption of food contaminated by pesticides (Goh et al, 1990; Swaddiwudhipong et al, 1989). This has been also been reported through the mass media in Kenya. In Latin America (Forget, 1991) and Africa (chapters 3 and 6; Ohayo-Mitoko et al, 1997a, 1997b; Mwanthi and Kimani, 1993; Mbakaya et al, 1994), occupational exposures seem to predominate. It is not clear whether this is due to cultural differences, differences in research methodology or under-reporting of cases. A recent paper (Parron, 1996) noted the sharp rise in the suicide rate among Spanish agricultural workers when organophosphorus pesticides were introduced into their areas. This corresponds with reports of unexplained high suicide rates among sheep farmers in Wales and the Scottish highlands (Sigmund, 1996), as a result of the governments insistence on the use of organophosphates, which are known to cause depression and sudden mood-swings, as well as confusion and anxiety; all predisposing factors for suicide. Many instances of poisonings of workers have been reported from Nicaragua and other Central American countries, particularly by the widely-used cholinesterase(ChE) inhibiting carbamates and organophosphates (Cole et al, 1988; Keiffer et al, 1992; McConnell and Hruska, 1993; Wesseling et al, 1993). Chronic occupational poisoning of Kenyan agricultural workers by pesticides and in particular, by organophosphate pesticides, has been documented (Mwanthi and Kimani, 1993; Ohayo-Mitoko et al, 1997a; see chapter 3).

As stated in chapter 1, studies on pesticide poisoning in developing countries have been few and most of them have addressed the health effects of occupational exposure to pesticides in general and the clinical effects of pesticide poisoning (Ohayo-Mitoko et al, 1997a; Wesseling et al, 1993; Mwanthi and Kimani, 1993; Mbakaya et al, 1994; Restrepo et al, 1990; Steinberg et al, 1989; Igbedioh, 1991; Khan and Sharique, 1993; Rastogi et al, 1989; Lopez de Alba, 1990; Rupa et al, 1991). Only a few have dealt specifically with the patterns of pesticide handling, knowledge and practices of agricultural workers (Mwanthi and Kimani, 1993; Manda, 1985). Infact, determinants of pesticide poisoning in general, have not been adequately evaluated nor have systematic prevention strategies for pesticide poisoning in Kenya, been developed. The study

presented in this chapter augments the studies that have been described in chapters 3, 4 and 5, by examining knowledge, reported and observed practices of agricultural workers with respect to pesticide handling, storage and use. The results will be used to formulate recommendations for interventions and prevention strategies, including guidelines for safe handling and use of pesticides in Kenya and elsewhere.

### **Study design, materials and methods**

This study was conducted in the follow-up period of maximum exposure (see Chapter 3) in the group of the exposed agricultural workers. Data have been collected in two ways. First *interviews* were conducted for the 390 agricultural workers in the study group. Secondly, *observations* were done in about 95% of all the farms. Out of 149 farms on which observations were made, 4.7% were from Naivasha, 65.1% from Wundanyi, 37% from Migori and 4.7% from Homabay.

#### ***Developing and refining procedures and study instruments***

Procedures for interviewing were developed, adapted and refined. The study questionnaire for assessing the knowledge, perceptions and recording the reported practices of agricultural workers was pre-tested and refined. The questionnaire had a combination of closed and open questions. It included questions on specific occupations of the agricultural workers, their level of education, duration of employment, whether or not they owned the land they were farming on, the nature of their work with pesticides and what precautions, if any were taken when working with pesticides. Further questions were asked on their knowledge as regards the most important routes of pesticide poisoning, decision-making on types and dosages of pesticides applied and storage of pesticides. Questions were asked on practices which included the disposal of empty pesticide containers and personal hygiene practices. Respondents were also asked whether their suppliers provided instructions on the safe-use of pesticides. The checklist for recording observations was also pre-tested and refined. In the observation checklist, techniques of mixing, spraying and storage were observed, first-hand, along with the availability, condition and use of personal protective equipment, cleaning and repair of application equipment, disposal of excess pesticide and empty containers as well as personal hygiene practices.

### *Recruiting, hiring and training staff*

Interviewers were recruited, hired and trained on the objectives of the project and in interviewing procedures to be used. The interviewers were recruited based on their ability to express themselves clearly when asking the questions and their knowledge of the various languages spoken within the four study areas. This was important as some of the farmers could neither speak English nor Swahili.

### *Interviews and observation checklists*

The interviewers administered a standardized questionnaire in English, Swahili or mother-tongue to each 390 exposed study subjects, at the end of the work-shift. The interviewers also filled in the observation checklists for 149 farms. This was to compare the observed and reported practices. The investigators observed the practices of the agricultural workers on large-scale farms, from the time they arrived on the farm, to the time they left after the workshift, some eight to ten hours later. For the small-scale farmers checklists were filled-in from the time the agricultural workers removed the pesticide from "storage", mixed and sprayed the crops, to the time they cleaned and stored the equipment. The workshifts which lasted for about four hours were, somewhat, shorter than those of agricultural workers on the large-scale farms because they had smaller plots and less pesticide to spray. Besides, as opposed to agricultural workers on the large farms who were employed as applicators and, therefore, expected to spray the whole day, small-scale farmers had other chores to perform, like digging, weeding and harvesting.

### *Data analysis*

Data have been analysed by descriptive and chi-square statistics. Frequencies were also obtained, through techniques of univariate analysis and cross-tabulations using SAS software (Version 611). The reported and observed practices have been combined.

## **Results**

Of the exposed agricultural workers who were interviewed (92.8%) were male while (7.2%) were female. The agricultural workers from area 1 were particularly younger than the average agricultural worker interviewed (area 1,  $27.8 \pm 7.1$  vs area 2,  $45.6 \pm 13.8$ ;

area 3,  $43.7 \pm 11.5$ ; area 4,  $39.4 \pm 11.3$ ). Two-thirds of the respondents (68.5%) had elementary level education while about one-third (27.7%) had secondary level education, and 3.3% had no education at all. As seen from Table 6.1, the main occupation depended on the area. The majority of agricultural workers were sprayers in area 1 and farmers in areas 2,3 and 4. In area 1, most of the agricultural workers were employed by others and so did not own the land on which they worked, while in area 2, most of the land was owned by the individual or/and family. Area 4 had the largest number of tenant farmers (see Table 6.1). Most of the respondents performed multiple jobs. In each of the areas, the nature of work with pesticides relates to spraying (88.1%), mixing (57.1%) and repairing (22.9%) and others like cleaning of equipment (6.0%) and driving the tractor with boom sprayer (see Table 6.2).

Patterns of pesticide handling...

**Table 6.1** Main occupation of the Exposed Agricultural Workers and Employed/Land Category.

Area	Main occupation				Employed/Land Category				
	driver	farmer	sprayer	supervisor	employed by others	family land	own land	tenant farmer	others
1	4.0%	2.7%	87.3%	3.3%	80.7	0.7	-	0.7	17.9
2	-	100%	-	-	4.9	(74.1)*	75.3	2.5	17.3
3	-	72.2	27.8	-	27.8	38.9	72.2	2.1	3.0
4	-	91.4%	4.8%	-	2.3	43.7	29.9	25.3	6.3
Overall					37.8	24.4	29.8	7.4	0.6

\* Note: Family land was sometimes described as own land.

None of the farms obtained their pesticides from the government; 63.1% obtained their pesticides from Co-operative Societies and 23.5% from the local store (stockist) while 14.5% obtained their supplies from other sources. In specifying their sources of pesticides, 18.5% reported that they obtained their supply of pesticides from the Horticultural Products Cooperative (HPC), 14.5% from Kenya Grain Growers Cooperative Union (KGGCU), 30.1% from other cooperative societies and stockists, 28.3% from the Tobacco Company, 4.7% from chemical companies while 3.9% indicated that they got their supplies from other sources, which included markets and smuggling from across national borders. A large number of the respondents (75.9%) reported that their pesticide suppliers gave them instructions on the safe use of pesticides; area 1 (88.7%), area 2 (48.1%), area 3 (77.8) and area 4 (79.3%). Table 6.3 gives an overview of the most commonly used pesticides in each area by pesticide group and chemical name.

Most of the equipment (92.5%) used were for spraying pesticide were different brands of knapsack sprayers while the rest were tractor/boom-sprayers, hose-sprayers, watercans and leaves.

**Table 6.2** Nature of Work with Pesticides

Nature of work	area 1	area 2	area 3	area 4	Overall
Spraying	87.3%	98.8%	94.4%	78.2%	88.1%
Mixing	35.3%	67.9%	94.4%	77.0%	57.1%
Repairing	9.3%	8.6%	55.6%	52.9%	22.9%
Other	8.0%	4.9%	3.8%	4.6%	6.0%

\* Note that the percentages do not add to 100% because some people did multiple jobs.

**Table 6.3** Most commonly used pesticides by pesticide group and chemical name

Area	Most commonly used pesticides by chemical name	Most commonly used pesticides by pesticide group
1	Lannate, Dithane M45, Benlate, dimethoate(methomyl), bifenthrin and cyhalothrin	Carbamates, organophosphates and pyrethroids
2	Ambush, propineb(antracol), Dithane M45 and ridomil(metalaxyl)	Carbamates, pyrethroids
3	Ambush, methadithion, Dithane M45 Cypermethrin	Pyrethroids, organophosphates
4	Dithane M45, ambush and dyrene heavy-metal based fungicides	Carbamates, pyrethroids and

### *Knowledge*

When given three alternative ways in which pesticides could enter the body during work, inhalation (85.4%) and dermal exposure (75.3%) registered high scores. Ingestion was given much less attention. The most important route is dermal exposure and it is important to note that most respondents, especially in areas 1,3 and 4 did not seem to know this. In area 2, 25.9% of the respondents were well aware of this fact (Table 6.4). Overall, about 55.9% of the respondents did not know any of the important ways of occupational exposure to pesticides.

**Table 6.4** Knowledge of the most important route for pesticide poisoning

Route	area 1	area 2	area 3	area 4	Overall
inhalation	23.3%	43.2%	72.2%	8.0%	26.3%
ingestion	8.0%	12.3%	5.6%	10.3%	9.5%
dermal	2.0%	25.9%	5.6%	1.1%	7.7%
not known	66.7%	18.5%	16.7%	79.3%	55.9%

When asked if they would stop spraying pesticides under any circumstances, 52.4% said they would. Of the people who indicated that they would stop, about 20% would stop if it was raining, and about 15%, when the headman says "stop". Other circumstances, like, when it was windy, hot, when the hose-pipe broke, or when the pumping machine broke down were only mentioned once or twice. It was noted that none of the farm-workers would stop spraying if they got accidentally contaminated with pesticides or stop to eat or smoke.

### *Use of pesticides*

Respondents were asked who made decisions on the types and dosages of pesticides used on the farms so that in any intervention, this would be the group to target. In Table 6.5 it is evident that in area 1, the employer or Foreman/Supervisor made most of the decisions on the type and dosage of pesticides to use on the crops. About 91.3% of the agricultural workers in this area indicated that they did not determine the dosages of pesticides, as they were almost all employed and did not own the land. In area 4, 94.2% of the workers indicated that they did not determine the types and dosages of pesticides used on the tobacco crop as these decisions were made by the tobacco company. In contrast, in areas 2 and 3, the farmer and his family members made this decision (74.9% and 84.5%, respectively).

**Table 6.5** Decision on the type of pesticide to use on the crops.

Decision	area 1	area 2	area 3	area 4
Take the cheapest	0.7%	1.2%	-	-
Take whatever is available	0.7%	18.5%	5.6%	-
Employer/Foreman/ company decides	90.0%	4.9%	16.7%	94.2%
Farmer and family	8.7%	74.9%	84.5%	5.8%

***Observed practices***

It was observed that mixing was sometimes done within the living house while, at times, it was done 7 km away from any foodstuff, living house or water source. There was no risk of pesticides entering a water source during mixing in 74% of the cases and the risk of contamination of the water source in 26% of the cases. At more than half (56.2%) of the farms observed, mixing was done in the knapsack, 33.6% in a bucket, then transferred into the knapsack, while the rest mainly on the large farms mixed in the boom-sprayer or in the tank for hose-spraying

***Storage of Pesticides******Reported***

Overall, 72.6% of the respondents indicated that they stored pesticides. The rest (37.4%), did not store pesticides at all and so either borrowed pesticide from other farmers or bought it from a stockist as and when required. Most of the respondents in area 1 who stored pesticides (96.0%) indicated that they did so in a pesticides store. This was similar, to a lesser extent, for areas 2 (43.2%), 3 (28.9%) and 4 (45.6). Other forms of storage included, under the bed, in the latrine roof, in the "attic", and even in the bush (Table 6.6). It was noted that one respondent from area 2 stored his pesticides in a tree on the farm.

*Observed*

About 46.3% of the farms, especially the small-scale farms, were observed to store all the pesticides around dwelling places. Of those, 21.5% stored pesticides in a room within the living house, 8.1% in the attic, 6.7% in a pesticide store while the rest either stored their pesticides in the eaves of the house, in the bush, in the latrine, in a tree on the farm or did not have any pesticides to store; they bought or borrowed them as and when needed. In most of the cases observed (88.6%), it was not possible for food, animal feed or water to be contaminated by pesticides. This risk existed in about 6.7% of the cases whereby the pesticide was stored next to drinking water or animal feed was kept in the same room. About 59.1% of the stores were dry, 52.3% well ventilated, 57.7% protected from sunlight, 53.7% protected from heat, 32.9% locked-up and only 7.4% stores had doors with warning labels. Only 5.5% of the farms, especially the large-scale farms, had an up-to-date inventory of pesticide supplies in the store. Infact, the rest did not have any inventory at all.

**Table 6.6** Reported storage of pesticides

Method of storage	area1	area2	area3	area4
Under the bed	-	6.2%	1%	1.1%
In the latrine(toilet) roof	-	2.5%	5.6%	2.3%
In a pesticides store	96.0%	43.2%	28.9%	45.6%
In the "attic"	-	4.9%	15.6%	9.2%
In a covered bucket in the store	-	1%	1%	1.1%
In the bush	-	2.5%	-	-
No storage*	-	33.3%	50.5%	0.5%

\* Borrowed from a Neighbour or bought from the Cooperative or pesticides' stockist, as and when required or bought and stored in the shop.

#### *Observed use and storage of equipment*

In 88.4% of the farms, the equipment were checked and assembled properly. In 73.3%, they were washed and cleaned after use, sometimes with water and soap but most times with water only. In 17.1% the equipment were washed on the farm, 8.9% in the store, 10.3% were passed on to the next farmer, while 14.4% were washed at home, near the dwelling house. About 11% of the farms observed stored the equipment in the pesticide store, 14.4% in a common store while 63% stored them elsewhere for instance in the dwelling house. Knapsack sprayers were mostly kept in the dwelling house or passed on to the next farmer. Boom-sprayers were parked together with tractors. There was pesticide left-over from previous applications on 4.8% of the farms and these had been stored in the knapsacks in the store or dwelling house and applied the next morning, after mixing it with some fresh pesticide.

### *Disposal of empty pesticide containers*

#### *Reported*

Empty pesticide containers were reported to be buried on 55.1% of the farms, burned on 38.1%, crushed on 18.4% punctured on 10.9%, used as drinking containers on 2.7% and used as feedstuff containers on 4.8% of the farms. Some other handling have also been mentioned, for instance, sold to scrap dealers. Note that the percentages add to more than 100% because most farms used more than one method of disposal.

#### *Observed*

The best ways to dispose of the containers is to burn (incinerate) or bury in a concrete-lined pit. Only area 1 burned (42.7%), threw away some into a large pit (48.0%) and buried the rest (5.3%) of the empty pesticide containers; area 3 threw away 77.8% their empty pesticide containers, as did area 4 (64.4%). In area 2 it has not been specified exactly how they disposed of these containers. It is possible that most of these containers were kept in the store and left untouched, retained by the employer or re-used for storing food, water and feed-stuffs.

### *Use of Personal Protective Devices(PPDs)*

#### *Reported*

Overall, 54.5% of the respondents reported taking precautions when working with pesticides. Area 1 (93.3%) reported the highest number of agricultural workers who took precautions when working with pesticides, followed by area 2 (46.9%) and area 3 (5.6%). None of the workers in area 4 took precautions while working with pesticides. Looking at the specific personal protective devices used or worn when working with pesticides, in area 1 boots were the most common, followed by gloves and overall. In area 2 headcovers, aprons and boots were most common. Handkerchiefs were the least used (Table 6.7). Related to employment category, it was reported that agricultural workers employed by others (93.7%) used more personal protective devices followed by those working on family land (51.3%) and working on own land (47.7%). Agricultural farmers who were tenant farmers reported the lowest use of personal protective devices (9.52%).

*Observed*

Gloves are essential when mixing pesticides. However only 8.9 % of the agricultural workers used good gloves ("in good shape"), while a further 2.1 % used defective gloves ("in bad shape"). The farmworkers in area 1 had more often, a better combination of personal protective devices. Most of the small-scale farmers rarely used gloves, respirators, aprons, boots, goggles and overalls. They, however, sometimes wore long pants and long-sleeved shirts (Table 6.8). Related to employment category, results of observations showed that as opposed to self-employed farmers, farmworkers employed by others took more precautions when working with pesticides (33.0%), used personal protective devices (40.9%), had facilities to wash or bathe (36.6%), washed and bathed (33.9%) and changed clothes (33.6%) after working with pesticides (Table 6.9).

*Personal hygiene*

Almost all farmworkers in area 1 reported to have a facility to wash or bathe (96.0%). In areas 2, 3 and 4, these facilities were less available (Table 6.7). In area 1, 92.7% indicated that they made use of these facilities, while 91.3% said that they changed clothes right after work (96%). Again these numbers were much lower in the other areas. During observations, personal hygiene was seen as "good" in 58.5% of the farms, "satisfactory" in 6.8% "fair" in 2%. About 33.2% of the farms had "poor" personal hygiene practices. In only 28% of the cases there was a washing facility in the vicinity of the mixing site, 10% in the vicinity of the spraying site, especially on the large-scale farms and 20% in the vicinity of the repairing site, usually at home for small-scale farmers. 70.1% of the farms had their workers wash their hands before eating; 67.3% with soap and plenty of water. Workers on only 30.6% of the farms changed their clothes immediately after spraying but only 19% washed protective clothing. It was found that while farmworkers employed by others scored highest with regard to personal protective devices and personal hygiene, those employed by tenant farmers scored the lowest.

**Table 6.7** Reported protective clothing/equipment worn when working with pesticides and personal care.

	area 1	area 2	area 3	area4
<i>Personal protective devices(PPD)</i>				
gloves	84.7%	3.7%	-	-
boots	92.0%	13.6%	5.6%	-
handkerchief	27.3%	2.5%	-	-
Headcover	53.3%	27.2%	5.6%	-
overall	84.7%	4.9%	5.6%	-
apron	43.3%	13.6%	5.6%	-
other	43.3%	14.8%	1%	-
<i>Personal hygiene practice</i>				
wash or bathe after the use	92.7%	55.6%	71.4%	69.0%
have a facility to wash or bathe	96.0%	70.4%	61.9%	62.1%
change clothes right after work	91.3%	48.1%	69.5%	65.5%

**Table 6.8** Observed personal protective devices (ppd) used during mixing, spraying and repair of equipment

PPDs	mixing		spraying		repair	
	good shape	bad shape	good shape	bad shape	good shape	bad shape
boots	23.3%	1.4%	25.3%	1.4%	18.4%	-
gloves	8.9%	2.1%	6.2%	-	4.1%	-
goggl	3.4%	1.4%	-	-	5.4%	-
head-cover	-	-	30.8%	10.3%	24.5%	8.2%
long pants	63.7%	12.3%	61.6%	14.4%	44.2%	8.2%
long sleeved shirt	42.5%	12.3%	41.8%	11.6%	31.3%	10.2%
overall	25.3%	1.4%	26.7%	2.7%	23.1%	1.4%
respi-rator	6.8%	-	6.2%	-	3.4%	-
shoes	14.4%	14.4%	10.3%	15.8%	9.5%	2.7%
apron	0.7%	-	0.7%	-	-	-

**Table 6.9** Employment Categories of agricultural workers and the use of protective equipment and personal hygiene.

Employment category	precautions	personal protective devices	facilities to wash and bathe	wash and bathe	changed clothes after
spraying					
employed by others	33.0	40.9%	36.6%	33.9%	33.6%
family land	5.1	8.8%	17.3%	15.2%	13.4%
own land	0.0	9.2%	20.2%	19.6%	17.3%
tenant farmer	0.0	0.7%	6.6%	7.1%	6.9%

***Cross-tabulations***

Cross-tabulations were done on agegroup (<30, 30-40, >40 years), level of education and the percentage of workers who reported to take any precautions when working with pesticides, use of personal protective devices and personal hygiene. Analyses show that in each age group most of the interviewees had no education or had elementary education (60.6%, 61.5% and 92.3%, respectively). The younger workers (agegroups ≤30 and 30-40 years) more often had secondary level of education (39.4% and 38.5%) than the older agegroup (7.7%).

As can be seen from Table 6.10, the younger agegroup (<30) scored the highest on all precautions. The older agegroup of more than 40 years scored the least in each case. Related to the level of education, secondary education scored highest on all precautions.

## Patterns of pesticide handling...

**Table 6.10** Agegroup, level of education and percentage of workers who take any precautions when working with pesticides, use personal protective devices, have a facility to wash or bathe, wash and bathe immediately after the use of pesticides, and change clothes right after work.

	take any precautions	use PPDs	have a facility to wash or bathe	wash or bathe	change clothes immediately
<i>Agegroup</i>					
0 - 30 years	77.7%	81.0%	90.9%	97.2%	95.1%
30 - 40 years	59.2%	64.8%	85.3%	94.7%	92.3%
> 40 years	35.9%	51.1%	78.5%	92.5%	89.5%
<i>Level of education</i>					
no education	50.0%	62.5%	87.5%	87.5%	100%
Primary	57.1%	67.5%	83.5%	94.6%	91.8%
Secondary	72.7%	74.7%	91.3%	96.7%	94.6%

## Discussion and Conclusions

The answers to the questions in the questionnaire forms were self-reported and subjective. As such, they may have introduced some bias into the study. However, when checked against the observed practices, most of the answers were similar. In addition, it was possible for the investigators to record, firsthand the worker's mixing and spraying habits as well as personal protection and hygiene practices. Since observations were done at farm level, rather than individual level, they could not be used to assess the actual reliability and accuracy of the farmers' self-reported use of pesticides as recommended by Blair and Zahm (1993).

The majority of agricultural workers interviewed were male. This is because most of the handling and application of pesticides is usually left to the male members of the households (notably the husband). The agricultural workers from area 1 were particularly younger than the average agricultural worker interviewed, probably because this was the area with the highest number of workers employed by others since employers tend to go for the younger and more able bodied males. Area 1 also had a bigger percentage of its workers with elementary and secondary education combined. In addition, it was the only area with predominantly male pesticide applicators and the highest number of workers designated as sprayers. Some of the sprayers did mixing, as well. One quarter of those interviewed were *equipment repairers* while 6% were *equipment cleaners* as well. In the other areas (2,3 and 4), where subsistence agriculture was practiced alongside some cash-crop farming, and workers were farmers who sprayed during the spraying season but also dug, weeded and harvested, the rest of the year. They were usually assisted by family members and occasionally, by hired labour.

Analysis showed that young agegroup, higher level of education and employment by others were positive factors in the use of PPDs, personal hygiene practices and knowledge on important routes of pesticide poisoning. This result is supported by other research. For example Mwanthi and Kimani (1993) found that the level of education significantly correlates with the preparation of agrochemicals according to instructions. Similarly, the relationship between the level of education and use of personal protective devices (PPD) while spraying the chemicals was found to be statistically significant. Anon (1992a)

reported that low levels of education and training of the agricultural workforce make the workers particularly vulnerable to the risks of accidents and occupational diseases. For example, an illiterate worker cannot read the instructions on containers of toxic chemicals and, unless trained in another way, cannot follow safety procedures. The study reported in this chapter shows that a majority of workers had elementary education which probably does not enable them to read and understand instructions, especially when written in English. Thus, although a large percentage of pesticide containers observed in storage were labelled with mixing instructions many of the agricultural workers may not be able to read them. Although we did not study the contents of the labels on pesticide containers, they probably are complicated anyway. A study carried out in Sri Lanka, to try and identify the usefulness of pesticide labels as an information source for farmers found that they were only able to recall, on average, 2 out of 17 label items. There was, generally, a poor understanding of units, codes and symbols and specified dosage and pre-harvest intervals were rarely adhered to (Sivayoganathan and Ramanabharathy, 1994). Another survey carried out in the Cameroon cotton belt on farmers' understanding of FAO's pictures aimed at illustrating the safety measures to be taken in the use of pesticides. Of the 13 drawings proposed to complete labels of chemicals, 4 appeared to be suitable, since their meaning was understood by over 90% of the respondents. All the others led to dangerous or erroneous interpretations (Torneux, 1994). This means that in the promotion of safe use of pesticides by farmworkers it is necessary to pay special attention to the way in which instructions on safe use are depicted on labels on the pesticide containers.

There are three possible routes of entry of chemical pesticides into the body; dermal absorption, inhalation and ingestion. It should be noted that more than half of the interviewees did not know any route at all (55.9%). The interviewees mentioned inhalation most often as an important route (26.3%). Workers tend to associate strong smells with toxicity. This is dangerous because they may feel safe while applying a very toxic fumigant like, methyl bromide, simply because it does not have a smell (except when laced with chloropicrin).

It is commonly accepted that under field conditions dermal contamination is the most significant of the three routes as mentioned (Ambridge, 1988). However, overall, only

7.7% of the farmworkers were aware of this route. Bonsall (1985) concluded that the potential for dermal exposure was greater for knapsack spraying than for other types of spraying operations (i.e. tractor based spraying). Since in our study most of the spraying was done with knapsack sprayers, farm workers should be educated and this wrong perception corrected.

The risk of an agricultural worker becoming poisoned by ingestion is a remote one, unless the chemical has a high oral toxicity and they are inordinately careless about their eating or smoking habits and personal hygiene (Goulding, 1985). Sprayers should stop spraying when it is raining, but only 20% of the interviewees reported to do so. Other situations, like when it is too hot, or when they get accidentally contaminated were only mentioned occasionally. Infact, in such cases they should clean their clothes and bodies with plenty of water and soap and change their clothes and personal protection devices before resuming to spray.

Mixing of pesticides is a major risk for farmworkers. Mixing was sometimes done within the living house or close to a water source. Contamination was also likely to arise from kitchen utensils and crockery (saucepans, buckets, kettles and spoons), being used for mixing and stirring pesticides before it is poured into the application equipment. Also, water sources could be contaminated through spills and run-off in one quarter of the farmworkers interviewed, making this an important route for occupational/environmental poisoning. Mixing is also a major risk because of the very high concentrations of the mixture, before dilution. It is usually safer to mix the pesticides in the application equipment as this reduces chances of exposure to the concentrated chemical. However, one third of the workers mixed pesticide in other containers before transferring it into knapsacks, further increasing possibility of spilling it all over themselves and the floor/ground, in the process. Mixing pesticides and loading sprayers has been identified as a major hazard in other studies as well. Craig et. al. (1993) demonstrated that a significant proportion of total exposure occurs on the hands during measuring and pouring small quantities of the concentrated pesticide product. Handling of the pesticide concentrate gives rise to more exposure than the spraying itself because the chemical is, often, 50-90 times more concentrated (Bonsall, 1985).

Three-quarters of the farmworkers stored pesticides. The other one quarter were mainly small-scale farmers who did not store any pesticides but bought or borrowed pesticides as and when needed. Area 1, with large-scale farms, stored almost all their pesticides in pesticides stores while in areas 2 and 4 almost one third of the farmers did so. In area 3 one half of the farmers did not store pesticides at all. In the majority of cases, there was no possibility of contamination of food, animal feed or water, as a result of pesticides storage. However, farmers without pesticides stores should be encouraged to build them according to the recommended specifications. At the same time, efforts should be made to improve the design of the existing stores to make them lockable, dry, well-ventilated, protected from sunlight and heat, and the doors labelled for caution.

It is important to note that 95% of the farms did not have any inventory of pesticide supplies in the store. This is an issue that should be addressed urgently as it would enable inspectors, researchers, doctors and agricultural extension agents to check the pesticides used and advise the farmer accordingly.

With regard to the disposal of pesticide containers, only area 1 did so in a socially and environmentally acceptable manner, that is, in 96% of the cases they burned or buried the empty containers. In the other areas empty containers often were thrown away or even re-used for household purposes. However, under no circumstances should pesticide containers be re-used for storing food, feed or water for consumption by human beings or domestic animals.

Storage of equipment shows results in the same direction. Two-thirds of those interviewed stored the equipment in the dwelling house/elsewhere and not in a pesticide store or common store. These results altogether indicate that there is a need to educate farmers on safe storage of pesticides and equipment and on safer methods of disposal for pesticide containers.

Overall, only half the respondents used personal protective devices (ppd). Most of these were from area 1. Although almost all the workers in area 1 (most of them employed by others) had ppd and scored highest on personal hygiene practices, the results presented in

chapter 3 showed that they experienced the largest cholinesterase inhibition (see also Ohayo-Mitoko et al., 1997a). This is probably because they either did not use the ppd all the time or used them incorrectly. The workers from area 1 also had the most frequent exposures from high concentrations of extremely hazardous pesticides. This could have resulted in the dramatic inhibitions reported in chapter 3. Farmworkers employed by tenant farmers scored the lowest with regard to ppd and personal hygiene. Personal protective devices are expensive and so most small-scale farmers cannot afford them. In any case, they are also uncomfortable, especially in tropical climates. Besides, the less educated small-scale farmers may not be able to use them correctly. Instead, the use of less hazardous pesticides (Class II and especially III) and Integrated Pest Management practices, should be promoted as it would be expensive and unrealistic to expect the small-scale farmers to buy ppd and provide washing/bathing facilities on the farm so as to use pesticides "safely". In any case, personal hygiene practices were observed to be much worse than was reported by the agricultural workers.

About 92.5% of the equipment used by the respondents were knapsack sprayers. Pesticide calibration was not carried out so application rates were, invariably, guessed at. Operators regularly performed hazardous operations such as decanting organophosphorus pesticides and other WHO Class I pesticides, using bottle-tops from, sometimes, unmarked bottles. In addition, some of the spray machines, especially owned by small-scale farmers, were very basic hand-operated types, often having no proper nozzles. They were of inferior quality and often broke-down and leaked pesticide formulation onto the operator. Infact, with such knapsacks and applicators, WHO Class I pesticides, the most acutely toxic pesticides, are too hazardous to use in Kenya. In targeting reduction in the use of hazardous pesticides (WHO Class Ia and Ib, WHO Class II - hazardous in conditions of use in developing countries e.g., paraquat, parathion), it is important to know who makes decisions on the types and dosages of pesticides used on the farms. In area 1, the Foreman/Supervisor should be targeted, while in areas 2 and 3, the farmer himself and his family should be the targets. In area 4, the farmer and the tobacco company should be targeted.

Cooperative societies (Mbakaya et al., 1994) and the tobacco company have been confirmed to be the largest outlets for pesticides to the farmer and should be targeted during the intervention stage. A substantial amount of pesticides are also obtained through illegal ways and unless this is addressed, the national pesticide regulatory body (PCPB) will not succeed in controlling banned/hazardous pesticides. Although many respondents stated that pesticide suppliers gave instructions on safe use, the results of this study indicate that the current instructions do not lead to safer practices. The pesticide suppliers should be sensitized and educated on the need to give advise on the safe-use of pesticides, as they sell the chemicals.

It is evident from the facts above, that there is an urgent need to implement programs on prevention of occupational and environmental pesticide poisoning among agricultural field workers in Kenya and elsewhere, not only aiming at the agricultural workers, but also on the suppliers of pesticides and the foremen. It is expected that the results of this study will, hopefully, point the way to well-targeted preventive interventions.

The establishment of a suitable infra-structure could help minimize the adverse effects of pesticides on both the human population and the environment. This will need efforts in all areas of pest management and pesticide control. In addition, emphasis should be placed on the occupational health of workers in the agricultural sector, with appropriate medical surveillance and record keeping.

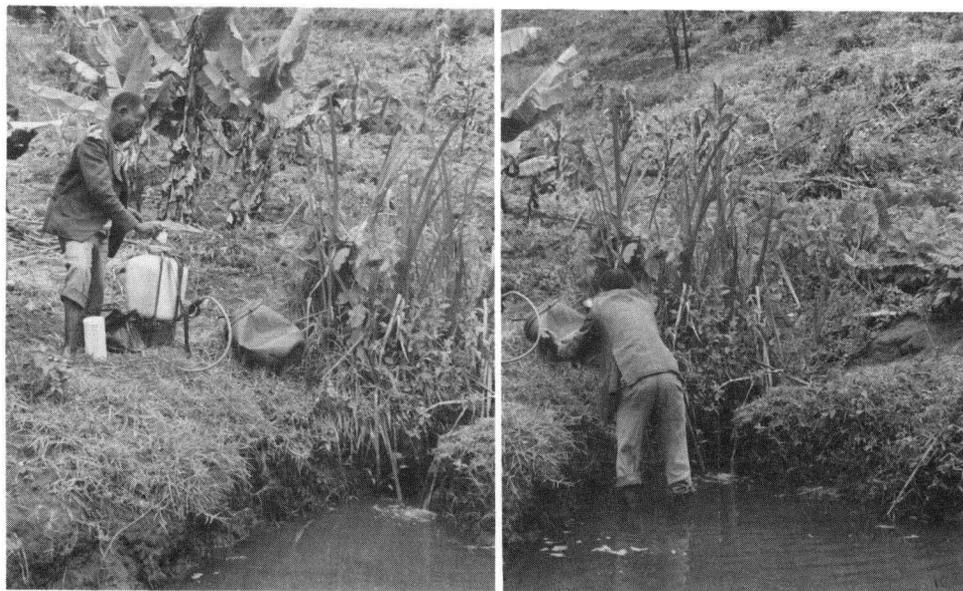


## Chapter 7

# Knowledge, perceptions and reported practices of Kenyan agricultural extension workers with respect to safe handling and use of pesticides

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*Submitted to Health Education Research*



## **Abstract**

The objective of the study reported in this chapter was to assess the knowledge, perceptions and practices of Agricultural Extension Workers (AEWs), with respect to the safe handling and use of pesticides within four study areas. A structured self-administered questionnaire in English was distributed to 120 AEWs and completed by 86 AEWs. Results showed that 33% of the AEWs did not know the pesticide operations responsible for poisonings and only half of the respondents knew of the potential hazards of the different pesticides used within their respective areas. Moreover, 68% of the AEWs perceived pesticide poisoning as a minor problem or not a problem at all. All the respondents reported that they had dealt with agricultural pesticides in the course of their work and had been involved in advising farmers on safe-use, with emphasis on following instructions on the labels, use of personal protective clothing and devices, and personal hygiene. In addition, they emphasized proper storage in dry, locked-up stores with adequate ventilation, away from direct sunlight and away from the potential danger of fire or explosion.

Although all the respondents were aware that pesticides could enter the human body during occupational exposure it was clear the majority of them did not know the specific First Aid procedures. The results of this study underline the need for an awareness campaign and health education programmes for AEWs in order to increase their knowledge and influence their perceptions as well as facilitate improvements in their practices with regard to the safe use of pesticides in crop protection. In addition, there is a need to encourage farmers to adopt safer and more environmentally sustainable methods of crop protection like Integrated Pest Management. This will hopefully enhance the quality of life of the farmer and his family.

## Introduction

The Agricultural Extension Worker (AEW) is a very important link, in the flow of information on crop production and crop protection, to the farmer. It is, therefore, imperative that the AEW is well-trained and has adequate knowledge on the safe-use of pesticides if pesticide poisoning is to be prevented in developing countries. Studies on the knowledge, perceptions and practices of Kenyan agricultural extension workers with regard to the use of pesticides have not been undertaken. Yet the contribution of the AEW is vital if farmers are to achieve good yields from their plots, some of which are usually quite small. AEW's are expected to educate farmers in, among other things, the safe handling and use of agrochemicals at farm level. In order to do this, they must be well versed with safe use of agrochemicals.

The studies presented in the previous chapters have revealed that most agricultural workers have very little knowledge (Chapter 6) if any of the risks associated with pesticide poisoning due to occupational exposure and do not seem to have received appropriate training in the handling of these chemicals (Ohayo-Mitoko et al., 1997a, 1997b). Health and safety issues are exacerbated by a general lack of hazard awareness, lack of protective clothing, or difficulty of wearing protective clothing in tropical climates and shortage of facilities for washing after use, or in case of accidents. Other factors include the value of containers for re-use in storing food and drink, illiteracy, labelling difficulties relating either to language, complexity or misleading information and lack of regulatory authorities and enforcement (Forget, 1990; Ohayo-Mitoko et al., 1997b). In addition, agricultural extension is not often oriented to the transfer of information related to the dangers inherent in the use of pesticides. According to Forget (1991), lack of information at all levels may be one of the most important causative factors of chemical intoxication in developing countries and research should, therefore concentrate on behaviours leading to poisoning.

In Africa, farmers in Kwara state, Nigeria reported that they usually sought information on marketing, pesticides, herbicides, fertilizers, improved seeds, improved agricultural practices, credit and storage from the mass media, fellow farmers and the extension agents (Olowu and Igodan, 1989). Baliddawa (1991) in a study on agricultural extension

and pest control in Iganga district of Uganda, found that information on pest control was scanty. Although the majority of farmers were aware of the presence of pests, there was minimal pesticide use on small-scale farms. Infact, the number and types of pests varied between the farms and the indispensable extension staff were too few to handle even the general aspects of crop production, let alone the important issue of crop protection. These AEW, therefore, did not have the time to train workers on the use of pesticides as well as the prevention of pesticide poisoning. Jellinek and Joannides (1992) emphasised the critical role the field communicator in agricultural extension plays between the farmers within the same and different areas and between government/private agencies and farmers in Australia. In a study in Turkey, it was found that plant protection decisions of 50% of the growers were influenced by extension officials while only 25% were influenced by the agrochemical dealers (Yigit et al., 1994). The experience of extension workers in the field of crop-protection should be imparted to farmers to enable them to address the toxic and environmental hazards associated with the use and misuse of pesticides (Schab, 1989). Extension workers have been found to encourage safe and effective application of herbicides in India. They were found to give advise on correct herbicide choice, its storage, selecting appropriate application times, preparing sprays and using equipment correctly. They were also reported to emphasize the importance of safety precautions in handling herbicides and equipment at all stages (Ray, 1989). Baca and Gonzalez (1994) developed an extension model and training needs for IPM where the extensionists assumed the technical assistance, training and implementation of knowledge.

The aim of the study reported in this chapter was to assess the knowledge, perceptions and practices of Agricultural Extension Workers in Naivasha, Wundanyi, Homabay and Migori districts of Kenya with respect to safe use of pesticides. The objective was to identify the inadequacies that exist in these individuals, which need to be addressed if our farmers are to learn from the agricultural extension workers the proper way to safely use and handle agrochemicals, and first aid techniques incase of occupational pesticide poisoning. The AEWs are professionals employed by the Kenyan Ministry of Agriculture, Livestock Development, Supplies and Marketing and Tobacco Companies to give advice that the farmer needs pertaining to crop production and crop protection. This includes, how and when to plough, the variety of seeds to be used, crop protection including the

use of pesticides and integrated pest management (IPM), when to harvest, whether or not to intercrop and how.

## **Study design, materials and methods**

### ***Study group***

The study group consisted of 120 Agricultural Extension Workers (AEWs) (see Table 7.1), who worked within a 15 km radius of each of the farms or estates studied as described in Chapter 3 (Ohayo-Mitoko et al, 1997a). This comprised of different cadres of agricultural extension personnel and included agricultural assistants, field assistants and agricultural field officers.

***Questionnaire:*** A self-administered structured questionnaire in English was distributed by the investigators to 120 Agricultural Extension Workers (AEW). Information was obtained on occupations of Agricultural Extension Workers (AEW), duration of employment in agricultural extension and in the particular agricultural area, whether or not they dealt with pesticides and what kind of advise they gave to farmers on the use of pesticides. Further information was also obtained on their knowledge on whether or not pesticides could enter the human body and which pesticide operations were responsible for pesticide poisoning. The AEWs were also interviewed on whether or not they were aware of any potential health hazards related to the use of pesticides, whether pesticide poisoning was a problem in the communities they served and which pesticides, by chemical name, group and trade name were responsible for pesticide poisoning. In addition, the respondents were asked if they knew first aid procedures for pesticide poisoning, which they were asked to describe. Finally, the AEWs were asked what they thought were the most effective ways of preventing work-related pesticide poisonings.

***Data analysis:*** Data analysis was by descriptive statistics. Frequencies were obtained, through techniques of univariate analysis and cross-tabulations, using SAS software (SAS Version 6.11).

## Results

### *General characteristics of the respondents*

Of the 120 selected AEWs, 86 completed questionnaires. This is a response rate of 72%. Most of the Agricultural Extension Workers were males (89.5%) and 10.5% were females with an age range of 25 to 54 years, the majority (46%) being between 31-40 years, 30% were between 20-30 years of age and the rest (24%) were above 40 years of age (Table 7.1). Of the various cadres of AEWs, 69.5% were agricultural assistants, 17.4% field assistants and 13% agricultural officers. The duration of their service in agricultural extension varied from 1.5 to 34 years with 75% having worked for upto 15 years while the rest had worked for 15-34 years. About half (47%) had worked in agricultural extension in this particular area for between 1 and 5 years, another 40% had worked for 6-15 years in this area, while the rest (13%) had worked in this area for more than 15 years.

**Table 7.1** General Characteristics of the Agricultural Extension Workers

	N	Mean age	SD
Overall	86	38.2	9.0
Male	77(89.5%)	38.0	9.2
Female	9(10.5%)	40.0	8.0

### *Knowledge*

All the Agricultural Extension Workers interviewed indicated that pesticides could enter the human body. With regard to the pesticide handling operations responsible for occupational poisoning, 70% mentioned storage, mixing, spraying, lack of protective gear, poor equipment, poor personal hygiene and poor disposal of leftover pesticide and empty pesticide containers. The rest (30%) did not seem to be aware of the specific pesticide operations responsible for poisonings. However, all the respondents were aware that pesticides could enter the human body.

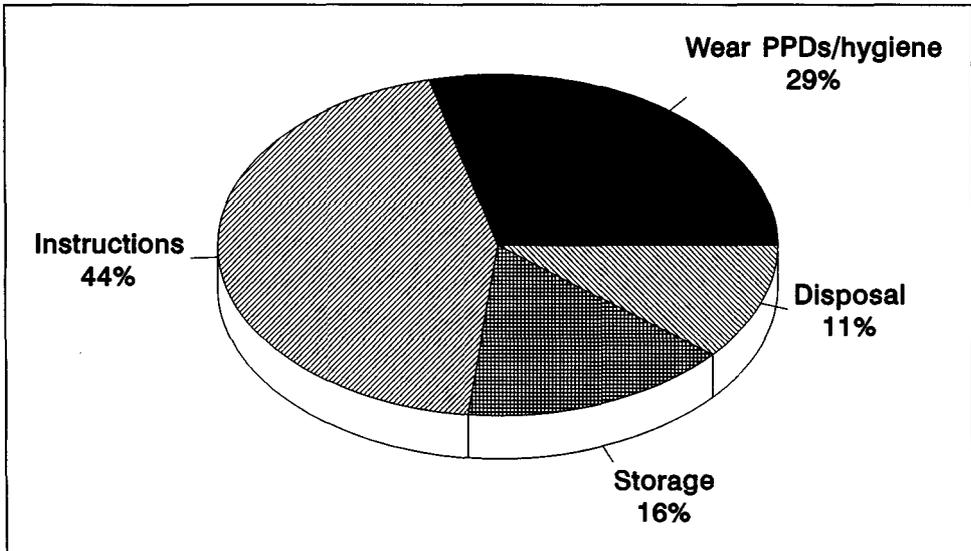
Over half (52.2%) of the respondents were quite well aware of the potential health hazards of the different pesticides used in their respective areas while 43.5% were aware of only some of these hazards. The rest (4.3%) were not at all aware of any hazards associated with pesticide poisoning. The pesticides mentioned as responsible for poisoning were: ambush, sumicidin, diazinon, dithane M45, politrin, aldrin, ridomil, cocid, orthene, rogor E, methyl bromide, mocarp, bayleton, cooper, karate, malathion, nemacure, antracol, actelic, roundup, gramoxon, coopertox and benlate. Of those interviewed, 96.4% of the agricultural assistants, 87.5% of the field Assistants and 66.7% of Agricultural field officers reported that they knew first aid procedures for pesticide poisoning. A majority of the respondents (84.8%) were aware of the most effective ways of preventing work related pesticide poisoning. Field assistants and agricultural assistants most often mentioned wearing of protective clothes (75% and 54% respectively) as the most effective ways of preventing work-related pesticide poisoning. Field officers, on the other hand, most often mentioned following instructions (40%) and proper storage (40%) (Table 7.2).

### *Perceptions*

About one third (32.6%) of the respondents felt that pesticide poisoning was a major problem in the communities in which they worked, 47.8% felt it was a minor problem while 19.6% did not think pesticide poisoning was a problem at all.

### *Practices*

All the respondents reported that they had dealt with agricultural pesticides in the course of work and had been involved in advising on agricultural pesticide use. All the respondents gave relevant advise to farmers on the use of pesticides, which included, among other things, instructions for proper handling of pesticides (44%), use of protective gear, clothing and personal hygiene (29.0%), storage (16.0%) and disposal (11.0%) of leftover pesticides and empty containers (Figure 7.1).



**Figure 7.1:** Advise given on the use of pesticides.

All the agricultural field officers and over 80% of the agricultural assistants and field assistants gave advise to farmers about the safe-use of pesticides. The agricultural assistants gave more advise on the "instructions for safe-use" (53.6%) , the field assistants on "wearing of personal protective devices" (57.1%) and the agricultural field officer stressed "proper and safe storage" (50%). Only the agricultural assistants gave advise on the disposal of empty pesticide containers (Table 7.3) and also recommended the use of cultural methods and proper labelling of pesticide containers as effective ways of preventing work-related pesticide poisoning.

**Table 7.2.** Occupation and recommendations on the most effective ways of preventing work-related pesticide poisoning.

Occupation	Follow instructions	Use of cultural methods	Wear protective devices	Proper disposal	Proper storage away from foodstuffs
Agricultural Assistant	19.2%	3.9%	53.9%	7.7%	15.4%
Field Assistant	25.0%	0.0%	75.0%	0.0%	0.0%
Agricultural Field Officer	40.0%	0.0%	20.0%	0.0%	40.0%

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**Knowledge, perceptions and...**


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**Table 7.3. Occupation, giving advise about the use of pesticides and the kind of advise given to the farmers.**


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Occupation	Advise on the use of pesticides	Personal protection	Instructions on safe use	Storage	Disposal of containers
Agricultural Assistant	82.14%	28.6%	53.6%	7.1%	10.7%
Field Assistant	87.5%	57.1%	28.6%	14.3	0.0%
Agricultural Field Officer	100.0%	16.7%	33.3%	50.0%	0.0%

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**Reported recommendations**

The respondents overall, recommended the use of protective clothing (43.5%), following instruction on the pesticide labels (17.4%), proper storage and disposal of pesticides and empty containers (17.4%) and proper labelling of pesticides by the manufacturers (4.3%) and use of cultural methods of cultivation , such as crop rotation (2.2%). Other recommendations made were, appropriate farming methods to reduce the use of pesticides (IPM), ensuring spraying equipment in proper working order, proper personal hygiene and spraying at appropriate times towards the wind direction (15.2%) (Figure 7.2). A majority of the agricultural assistants gave advise on "instructions on safe use" while more field assistants gave more advise on "personal protection" and most of the agricultural field officers gave advise on "storage" (Table 7.2).

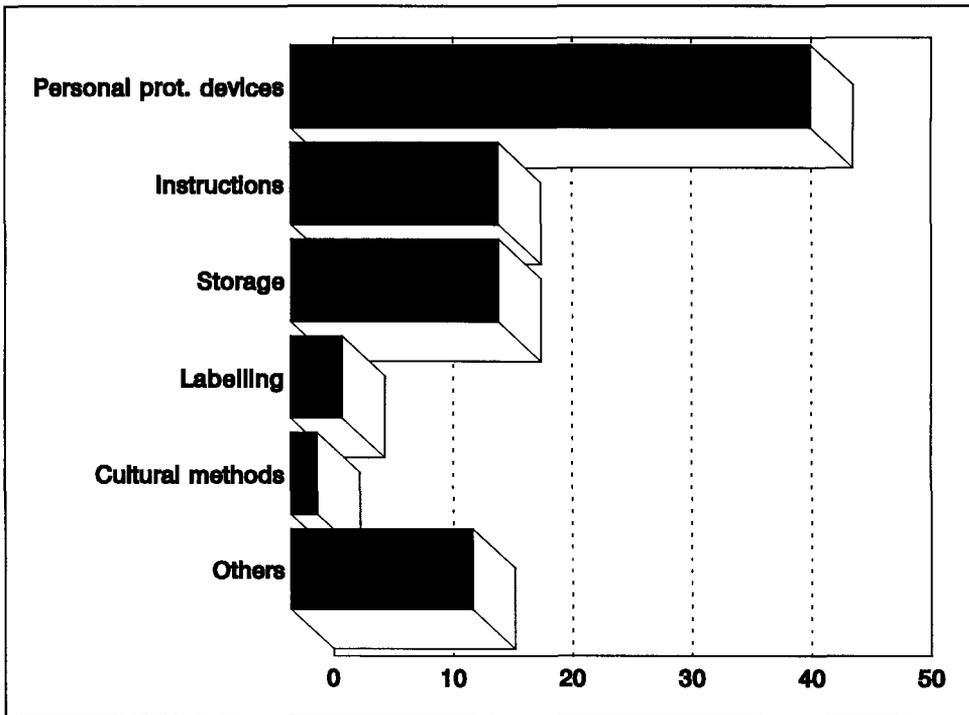


Figure 7.2. Reported recommendations made by the extension workers.

### ***First aid***

Most of the agricultural extension workers (89.1%) reported that they knew the correct first aid procedures while 11.9% reported that they did not know the first aid management procedures that they would administer in case of pesticide poisoning. Of the various first aid management techniques, 30.8% indicated that the victim should be removed from the dangerous environment, application of artificial respiration (23.1%), induce vomiting by giving milk mixed with cowdung or sheeps fat, raw eggs (15.4%), use of alkaloids, medicinal charcoal, salt solution and ashes (5.1%) and referral to a hospital/clinic/-dispensary/ or call medical doctor (with the causative pesticide container or label) (25.6%).

### **Discussion and Conclusions**

The questionnaires were self-administered and answers to the the questions were self-reported and subjective. As such, they may have introduced some bias into the study. In addition, some of the respondents may have needed clarification of certain questions but did not ask for it for a variety of reasons.

The response rate of 72% was quite good as agricultural extension workers are mobile and may not be in a particular place when you need them to return the questionnaire or clarify some issues. Such is the nature of their job. There was a wide range of crops grown in the study areas, especially in Naivasha and Wundanyi. There was, therefore, the need to use different pesticides.

Most of the agricultural extension workers were male, the majority being agricultural assistants. Most of these agricultural extension workers had worked in extension for quite a long time. Over half the respondents had worked in the particular agricultural areas for six years or more and so had good knowledge of the areas and the farmers.

Although the AEWs knew that pesticides could enter the human body, 30% did not know the pesticides operations responsible for occupational poisoning. Only half of the respondents reported that they were aware of all of the potential hazards of the different pesticides used in their respective areas and mentioned them. The rest were either

unaware at all or aware of only some of these hazards. Only one third of the respondents perceived pesticide poisoning as a major problem in their community. All the respondents had dealt with agricultural pesticides in the course of their work and had been involved in advising farmers on safe-use, with emphasis on following instructions for the proper handling of pesticides, use of personal protective clothing/devices and personal hygiene, as well as the proper storage of pesticides. Almost 90% reported that they knew the correct first aid procedures, in case of pesticide poisoning. However, some of the First Aid procedures that they described were general and not specific to pesticide poisoning. There is, therefore, need for training in the appropriate procedures for First Aid in pesticide poisoning, which is a very important component in the management of pesticide poisoning. This shows a very low level of awareness and knowledge and underlines the need for urgent interventions through awareness campaigns and health education to increase their knowledge and improve their perception of this problem.

The disparity, by cadre, in the most effective way of preventing work-related pesticide poisoning, signified a difference in knowledge and perceptions between the different cadres of AEWs. This could mean different approaches and emphasis during the implementation of interventions. It was disappointing to note that only 2.2% mentioned cultural practices (as a component of Integrated Pest Management) whereas none of the respondents mentioned health education as the most effective way of preventing work-related pesticide poisoning. This is an indication that the respondents were not aware of the root-causes of pesticide poisoning in their communities. This underscores the need for education on the causes and effects of pesticide poisoning in the community and discussions with all the key players on how it can be prevented/controlled.

This study has confirmed that, a high proportion of pesticide intoxications appear to be due to lack of knowledge, wrong perceptions and dangerous practices. Agricultural extension is not often oriented to the transfer of information relative to the dangers inherent in the use of pesticides. This lack of information at all levels may be the most important causative factor of chemical intoxication in developing countries.



## Chapter 8

# Knowledge, perceptions and reported practices of health-care workers in the agricultural areas of Kenya on the diagnosis, management and prevention of pesticide poisoning.

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*Submitted to the American Journal of Industrial Medicine.*



## Abstract

The objective of this study was to assess knowledge, perceptions and practices of health-care workers (HCW) in four rural agricultural communities in Kenya with respect to diagnosis, management and prevention of pesticide poisoning. A structured self-administered questionnaire was completed by 108 HCW of different cadres. The results show that only 17% of the HCW perceive pesticide poisoning as a major problem. Knowledge of routes of pesticide entry into the human body was poor and inaccurate. One third of the respondents had never seen a case of pesticide poisoning. Only 20% of the HCW reported that they were able and had the necessary means to treat pesticide poisoning; 82% were able to provide information on health aspects of pesticides. However, only 8% of the information was directed to the farmers. Half of the workers gave information concerning pesticide storage and handling; 14% on first aid in case of pesticide poisoning; 3% on instructions for use, and another 3% on general awareness and health information. Almost all the health-care workers would like to be provided with drugs and antidotes for the management and treatment of pesticide poisoning, and they require equipment for gastric lavage, intra-venous sets and nasogastric tubes. They also indicated that they would require information and training on the health aspects of pesticide exposure. The results underline the need for health education programmes and in-service courses for HCWs, to increase their knowledge and influence their perceptions. This would also facilitate improvements in their practices with regard to the diagnosis, management and prevention of pesticides poisoning and training in the relevant methods of first aid for pesticide poisoning. In addition, there is a need to provide anti-dotes and equipment necessary for the management of pesticide poisoning. The HCWs should, together with the farm-owners, initiate surveillance programmes for prevention, early diagnosis and management of occupational pesticide poisoning.

## Introduction

It is important for all rural health practitioners to be familiar with agricultural practices and work environments in their local areas. Primary health-care workers should be able to recognize pesticide poisoning and to assess how and to what extent exposure may have come about. They should also be able to provide first aid and continuing management. If antidotes exist, as with organophosphate poisoning, they should be available and staff should be able to administer them. Specialized centres may prove invaluable in giving advice and should be readily accessible all the time (Levine, 1986). It is, also, necessary for rural health clinics, particularly in agricultural settings, to provide, not only primary health-care services, but also public health services, environmental/occupational health services and health education. However, the availability of sufficient numbers and types of well-trained health-care professionals willing to work in rural hospitals represents an additional constraint.

It should not be forgotten that, with a few exceptions, the treatment of pesticide poisoning is based on the general principles of non-specific resuscitation. A patient should be removed from contact with the noxious substance. Contaminated clothing should be removed at once and contaminated areas of the skin should be thoroughly washed. The eyes, if affected should be irrigated. Thereafter, management relies on sustaining the respiratory, cardiovascular, renal and fluid balance systems, and overall supportive care. It should be possible for patients to be transferred to hospital without delay. Elaborate toxicological analyses are seldom called for at this stage but they may be required subsequently for confirmation of diagnosis (Levine, 1986).

The key to improving health and safety must become a community activity in which peer pressure makes the message a personal one for the individual and family. The Zaltman and Duncan (1977) strategies for change, feature community development through coalescing community action. It has been demonstrated that people do not change health and safety behaviour until there is a personal reason for them to do so (Flay et al, 1980; McGuire, 1984). In addition, people are more likely to accept change if they are involved in the process of creating the change (Rowley, 1983; Koelen and Vaandrager, 1995).

Many professional groups have learned the rudimentary elements of being agents for change, including some professionals from each of the following groups; Farm Bureau, the Agriculture Extension Service, the county health department and the county development offices. Some committed citizens (key community leaders) have also learned these skills. Health-care providers can also learn to become agents of change. A critical element of change agency, is the ability to become a good facilitator, one who can enable the community to reach a consensus on identifying problems and solutions (Rowland, 1990).

In Britain, a report on pesticides and health by the British Medical Association (BMA) pinpointed a lack of training and awareness of pesticide-related issues in doctors, stating: "Not all doctors need to be expert toxicologists, but all doctors need to be aware of the possibility of disease resulting from toxic substances and to have more training and practical experience in the differential diagnosis and treatment of chemically-induced diseases (BMA, 1992). A common complaint from groups investigating pesticide abuses in Third World countries is the lack of training for doctors, and their failure to anticipate, or recognise, symptoms brought on by exposure to pesticides, particularly chronic, work-related exposure. It seems there is little training geared to help doctors. In South Africa, for example, there is no course or registered specialised field in clinical toxicology at any of the country's universities (Dinham, 1993). This problem has also been identified by the pesticide manufacturers' association, GIFAP, which is undertaking a project to improve pesticide safety in three Third World countries, notably Kenya, Guatemala and Thailand. The Guatemala project, in particular, has specified the need to train doctors to recognise symptoms of pesticide poisoning.

A greater problem in poor countries, and particularly in remote rural areas, is that medical care is frequently not available at all. Where pesticides are regularly applied on a large scale, such as plantations and estates, there is sometimes a clinic. However, this is often inadequate, with poorly trained staff and shortage or lack of antidotes. The medical officer frequently puts the estate-owners interests above those of the labourers. Should hospitalization be necessary, it can be many hours travel away.

Almost all countries have laws governing occupational health including occupational health in agriculture. The problem usually lies with enforcement of these laws and although the main purpose of the law is prevention of occupational diseases, it is difficult to prevent anything without sufficient knowledge (Vohlonen et al., 1992). Operational models needed to prevent farmers' occupational diseases are not known neither is there a model that can be used for organizing occupational health services for farmers (Vohlonen et al., 1992). Vohlonen et al. (1992) have suggested that three steps need to be taken to try and solve occupational health problems of farmworkers. These are, firstly, the occupational health inspection of the farm which includes observation and measurement of exposures which is very expensive. Secondly, health/medical examination of the farmworkers should be undertaken, in relation to the exposures observed. Last but not least, a health education component should be included, both for the farmworkers and health-care personnel, in the recognition of occupational exposures, health risks and their prevention. Health professionals get no agricultural health training, and as elsewhere, crowd into cities. Thus, limited agricultural preventive medicine is practised and rural populations do not get medical care equivalent to that in the cities (Vohlonen et al., 1992). Infact, centres of toxicological excellence in principal cities are of limited value if their facilities are not readily accessible to practitioners in the field (Levine, 1986). For too long now, experts have been making recommendations on this subject to no avail. To be effective, action should be launched at the village and field level (Goulding, 1988).

Apart from acute toxicity, chronic exposure to pesticides has been implicated to cause a variety of long-term effects such as sterility in males, birth defects, skin cancers, lung, kidney and nervous system damage (de Cock, 1995; Iorio, 1985). It is, therefore, important for health-care providers working in the farming areas to know how to diagnose, manage and prevent pesticide poisoning. Afterall, they are the first line of defence against pesticide poisoning for the farm-worker, after his own family, who may be engaged in farmwork and, therefore, more often than not, exposed to pesticides as well.

Since health-care providers play a pivotal role in management and treatment of pesticide poisoning by farmworkers, it is important to assess their knowledge, perceptions and

practices with respect to the diagnosis, management and prevention of pesticide exposure in Kenya. This is the specific objective of the survey reported in this chapter.

## **Study design, materials and methods**

### *Study group*

The study group consisted of 137 health-care workers, working in health-care facilities within a 15 km radius from the study areas described in Chapter 3. The group included physicians, clinical officers, registered nurses, public health nurses, enrolled nurses/midwife, nursing aides and health workers who worked in research institutes. The interviews took place in both the high and low exposure periods (see Chapter 3)

### *Consent to participate and Ethical Considerations*

The study was explained to all study subjects and written consent was obtained from those who agreed to participate. The participants were allowed to drop-out whenever they decided to. The proposal had been approved by the Ethical Review Committee of the Kenya Medical Research Institute, Nairobi, Kenya.

### *Questionnaire*

A self-administered structured questionnaire in English was distributed by the investigators to the selected health-care workers. The questionnaire consisted of both open and closed questions. Information was obtained on occupations of Health-Care Workers (HCW), duration of employment in health-care particularly in the specific agricultural area, whether or not they had dealt with pesticide poisoning at all, and if so, when and the number of cases that they had dealt with. Questions were also asked on the type of pesticides they knew, which ones caused pesticide poisoning in their areas of operation, the kind of treatment/management they administered for cases of pesticide poisoning, whether or not they had the facilities and drugs for management of pesticide poisoning and if not, the kind of facilities and drugs that they would require. The health-care workers were also asked what kind of information and advice they gave to farmers on the prevention of pesticide poisoning. Further information was also obtained on whether or not they felt that pesticides could enter the human body and if so, the most important routes of entry into the body. In addition, information was obtained on their need for

further training in the diagnosis and management of pesticide poisoning. Finally, the Health-Care Workers were asked what they thought were the most effective ways of preventing work-related pesticide poisonings.

### *Data analysis*

Data analysis was done by descriptive statistics. Frequencies were obtained, through techniques of univariate analysis and cross-tabulations using SAS Version 6.11.

## **Results**

### *General characteristics of the respondents*

From the 137 selected health-care workers 108 agreed to participate. The participation rate, therefore, was 78.8%. Of those interviewed, 47.2% were male and 52.8% female, varying in age from 21 to 52 years. Ninety per cent of the respondents were less than 45 years old (see Table 8.1).

**Table 8.1** General Characteristics of the study population

	mean age	SD	minimum	maximum	
males	47.2%	31.8	6.0	23.0	52.0
females	52.8%	32.9	7.7	21.0	51.0
all	100.0%	32.4	7.0	21.0	52.0

The professional cadres interviewed were Kenya Enrolled Nurse and Midwife (KEN/M) (77%), Kenya Registered Nurses (KRN) (6%), Nursing aides (4.5%), Clinical Officers (4.5%), Physicians (1.5%), Public Health Nurses (1.5%) and others, mainly Public Health Technicians and clinical anaesthetists (5%) (Figure 8.1). The type of health facility that they worked in were Health Centres (38%), hospitals (30%), Dispensaries (29%) and others, mainly private clinics (3%). All the physicians, all the clinical officers and 75% of the registered nurses were found in the hospitals whereas all the public health nurses and 45% of the enrolled nurses/midwife were found at health centres.

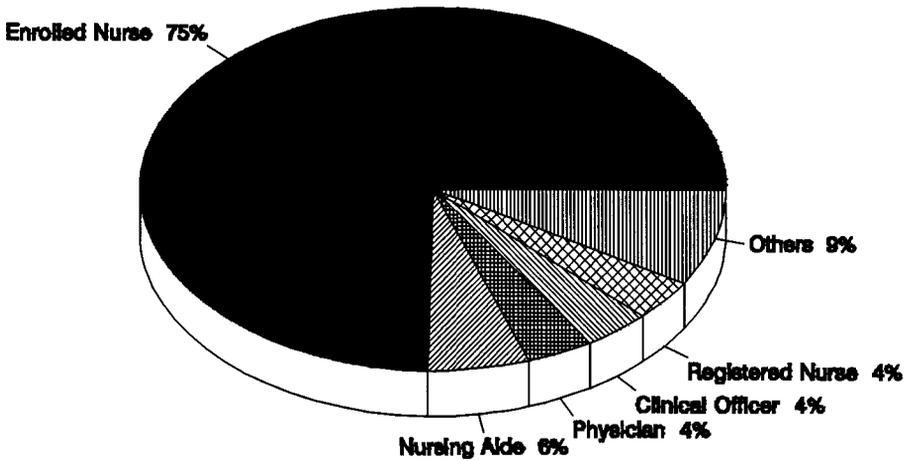


Figure 8.1: Professional cadres

The duration of service in health care as well as the duration of service in the specific agricultural area is shown in Figure 8.2. About three-quarters of the workers had been employed in health care between one and ten years. One third worked in the specific agricultural area for less than one year.

**Knowledge:** When asked to indicate the most important routes of pesticide entry into the human body, the respondents mentioned ingestion (68%), skin (4.5%), eyes (4.5%), cuts (4.5%) and inhalation (2.6%); 15% of the respondents were uncertain. Of these routes, ingestion was mentioned most often by all the cadres (Table 8.2). Although dermal exposure is the most important route of pesticide poisoning in occupational situations, only 25% of the physicians and registered nurses had this knowledge (Table 8.2).

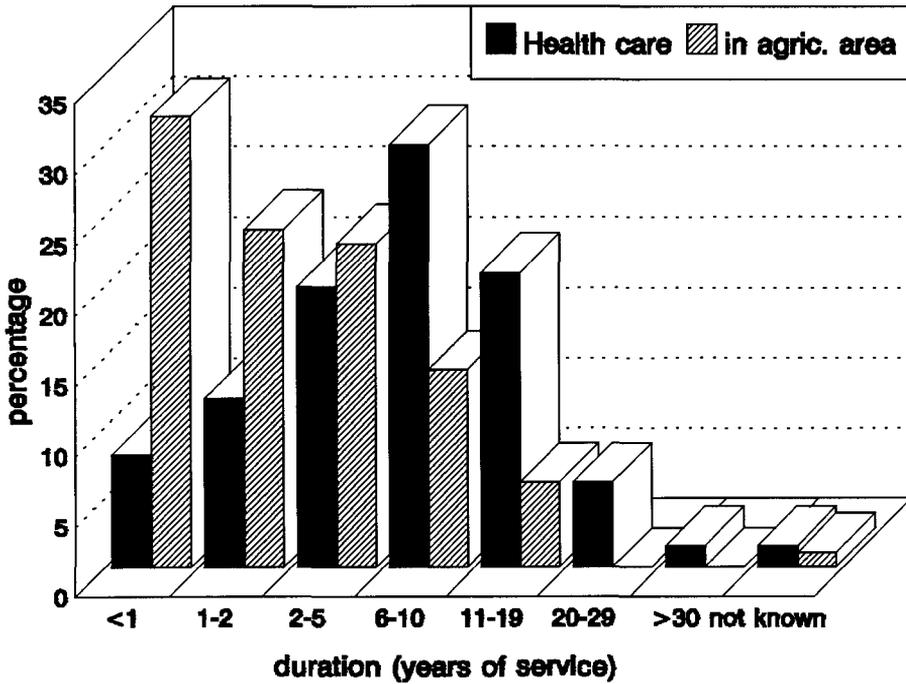


Figure 8.2: Duration of service in health-care compared to time worked in the agricultural areas.

Table 8.2 Occupation and the important routes of entry for pesticides

Occupation	Ingestion	Dermal	inhalation
Physician	75%	25%	-
Clinical Officer	66.7%	-	33.3%
Public Health Nurse	100%	-	-
Registered Nurse	25%	25%	50%
Enrolled Nurse /Midwife	75.3%	2.6%	20.8%
Nursing Aide	80%	-	20%
Research Institutes	73.7%	5.0%	21.3%

**Perception:** Of all health care workers 46% indicated that they perceive pesticide poisoning as a problem in the community they served, whereas 17% indicated that it was not a problem; 37% were uncertain. Of the respondents who felt that pesticide poisoning was a problem in the community they served, 46% indicated that it was a minor problem, 17% perceived it as a major problem and 37% was uncertain as to whether pesticide poisoning was a major or minor problem in their community.

**Practices:** Thirty percent of the respondents had never *seen* a case of pesticide poisoning during their period of service in health-care. The rest of the respondents (70%) had seen pesticide poisoning during their period of service in health-care, varying from 1 (17%) to more than 20 cases (17%). When asked about the number of cases in the period prior to the interviews (the past one month, past three months, the past six months and the past twelve months) it appears that most of the cases occurred in the past 6 to 12 months (Table 8.3). The physicians and enrolled nurses/midwife had seen more cases of pesticide poisoning than any other cadre of health-care workers (Table 8.4).

**Table 8.3** Cases of pesticide poisonings seen by the Health-Care workers in the duration of their service in health-care, as well as in the period prior to the interviews.

Cases of pesticide poisoning	entire period of service in health-care	past 1 month	past 3 months	past 6 months	past 12 months
0	30%	-	-	-	-
1	17%	9%	9%	14%	15%
2 - 4	20%	-	6%	10.5%	15%
5 - 10	8%	-	-	1.5%	12%
11 - 20	3%	-	1.5%	-	-
>20	17%	-	-	-	-
uncertain	5%				

About half of the respondents who had seen cases of pesticide poisoning (48.5%) were uncertain about the number of pesticide poisoning cases that had ever come to their *personal care*. Of the other interviewees 20% reported one case, 12% reported 2 cases, 8% reported 3 cases, 4.5% reported 4 cases, 3% reported 5 cases, 1.5% reported 10 cases, 1.5% reported 20 cases and 1.5% reported 70 cases (Figure 8.3). Sixty-one percent of the interviewees indicated that they suspected that there were pesticide poisoning *cases* which *did not come to the attention* of the health-care personnel, 18% said there were no such cases, while 21% were uncertain. The respondents felt that the majority of the unattended pesticide poisoning took place among the farm workers (24.5%), the youth (7.5%), middle-aged men (6%), children (4.5%) and the illiterate (3%). Of the respondents who suspected unattended pesticide poisonings, 73% were unable to give reasons for the unattended pesticide poisoning cases. The 27% who could give reasons for the unattended poisonings mentioned suicidal purposes (9%), negligence (45%), lack of knowledge (3%), inaccessibility of the nearest health facility (1.5%), lack of transport (1.5%), treatment by traditional doctor (3%), inability to follow instructions on the label (1.5%) and death before victim was attended to (1.5%).

**Table 8.4** Occupation and the number of cases of pesticide poisoning seen.

Occupation	No. of pesticide poisoning cases seen					
	None	1	2-4	5-10	11-20	> 20
Physician	-	25%	25%	-	-	50%
Clinical Officer	25%	50%	-	25%	-	-
Public Health Nurse	-	-	100%	-	-	-
Registered Nurse	50%	-	25%	-	25%	-
Enrolled Nurse/ Midwife	20.8%	13.0%	19.5%	15.6%	7.8%	23.4%
Nursing Aide	16.7%	33.3%	33.3%	16.7%	-	-
Research Institutes	66.7%	-	-	-	-	33.3

Overall, 67% of the health-care workers reported that they *treated pesticide poisoning*, 30% did not and 3% were uncertain. As can be seen from Table 8.5 all the physicians, clinical officers and public health nurses reported that they treated pesticide poisoning. In the other cases this varied between one third and two third of the workers. However, with the exception of clinical officers, all cadres experience a lack of the necessary *means for treatment*. More than half (58%) of the respondents reported that they did not have the necessary drugs and equipment for the treatment of pesticide poisoning. Of the health-care workers that indicated that they did have the means to treat pesticide poisoning (34%), 3% mentioned intravenous fluids, 1.5% hydrocortisone, 4.5% nasogastric tubes, 1.5% anti-acids, 8% antidotes like atropine. Remarkably, 82% of this group was unable to describe the means that they had for the treatment of pesticide poisoning. Relating the availability of means to occupation it appears that the clinical officers all report to have the means for treatment, while the public health nurses had none (Table 8.5)

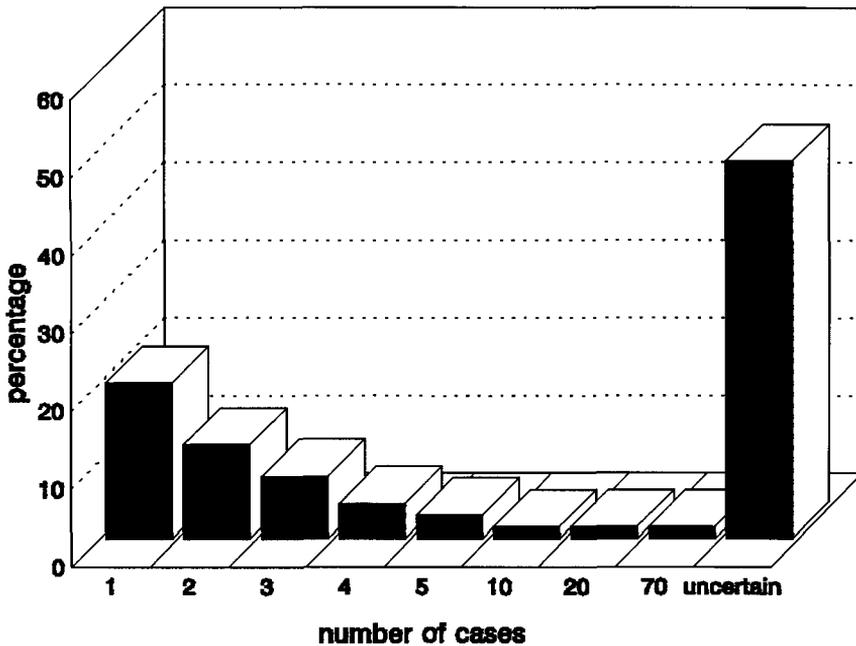


Figure 8.3 Number of pesticide poisonings that have ever come under the personal care of the interviewee.

Most of the respondents, especially the 58% who did not have the means to treat pesticide poisoning, indicated that they would like to be provided with drugs and antidotes (16.5%), 4.5% with chemicals for testing pesticide poisoning, 1.5% with hydrocortisone, 4.5% mentioned piriton, 1.5% Magnesium tricyclate, 4.5% anti-acids, 3% sodium chloride, 3% dextrose, 1.5% Ringer’s solution, 1.5% Hartmanfluid and 1.5% pethidine. They also indicated that they would like to be provided with equipment for gastric lavage (15%), Intra-venous sets (4.5%), nasogastric tubes (1.5%) and all facilities (1.5%).

Overall 82% of the health-care workers said that they *provided information* on the health aspects of pesticides while 11% indicated that they did not; 8% were uncertain. Public health nurses and registered nurses, in particular, provided this information (Table 8.5). When asked to whom the information was provided, 27% said it was to the Community, 23% to the patients, 8% to the farmers, 8% to the antenatal mothers, 4.5% to the victim’s relatives; 20% did not specify the target (Figure 8.4).

**Table 8.5** Occupations of Health-workers who treat pesticide poisoning, have the necessary means for treatment, as well as give information on health aspects of pesticide poisoning.

Occupation	Do you treat pesticide poisoning	Do you have the necessary means for the treatment of pesticide poisoning	Do you provide information on the health aspects of pesticide poisoning
Physician	100%	50%	25%
Clinical Officer	100%	100%	75%
Public Health /Nurse	100%	-	100%
Registered Nurse	50%	75%	100%
Enrolled Nurse /Midwife	64.1%	21.5%	86%
Nursing Aide	66.7%	50%	66.7%
Research Institutions	33.3%	50%	75%

The type of information provided included pesticide storage and handling (50%), First Aid in case of pesticide poisoning (14%), instructions for use (3%), general awareness (3%), health information (3%), while the rest was non-specific.

#### *Training requirements*

All the Clinical Officers, Public Health Nurses, Nursing Aides and Research Institutions, 96% of the Registered Nurses and half of the Physicians reported that they needed information and training on health aspects of pesticide poisoning. Fifty percent of the physicians and almost all of the rest of the health-care workers indicated that they needed information and training on the health aspects of pesticide exposure, with 92.4% indicating that they required information on prescription and treatment (management), 4.6% on diagnosis and 3% on the adverse health effects of pesticides.

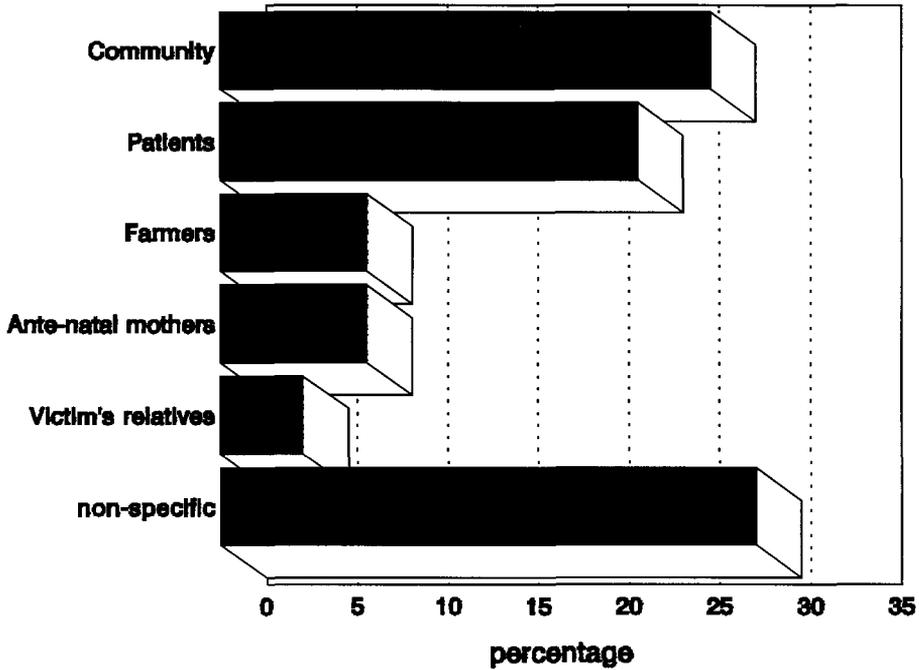


Figure 8.4: Groups advised on safe-use of pesticides

*Reported recommendations*

Interviewees also indicated that the most effective ways of preventing pesticide poisoning was through health education (33%), safe storage of pesticides (29%), following instructions on the labels (12%) use of non-chemical methods of pest management (12%), proper labelling (6%), keeping pesticides away from children (4%), personal hygiene (3%) and wearing of personal protective devices (1%) (Figure 8.5).

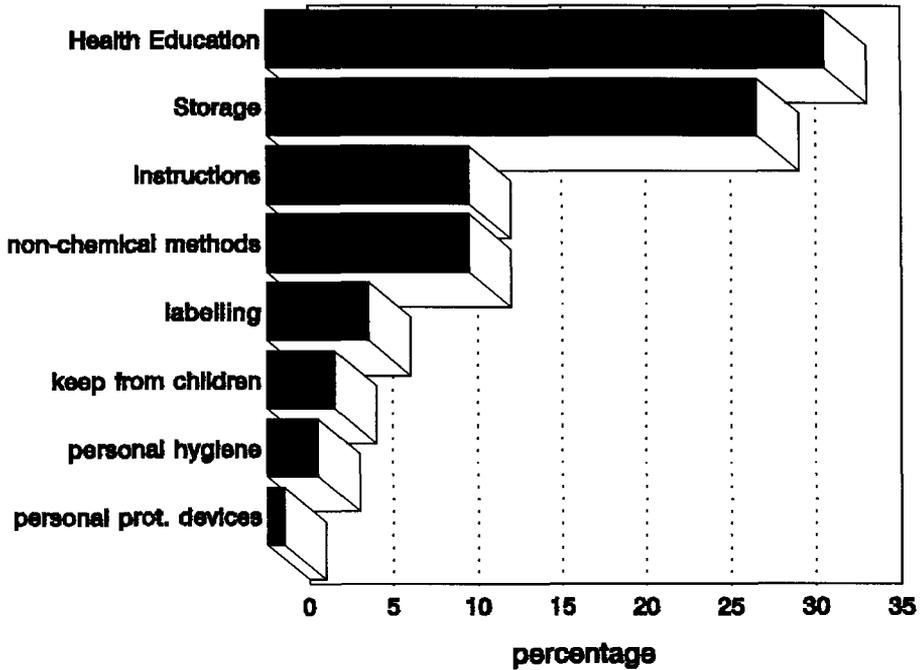


Figure 8.5: Most effective way of preventing pesticide poisoning

Half the number of physicians, clinical officers and registered nurses (50% each) and 32% of the enrolled nurses/midwife felt that health education to the community was the most effective way of preventing pesticide poisoning, followed by safe storage of pesticides and following instructions on pesticides containers (Table 8.6).

**Table 8.6** Occupation and the most effective ways of preventing pesticide poisoning.

Occupation	Ways of preventing pesticide poisoning					
	1	2	3	4	5	6
Physician	50%	25%	25%	-	-	-
Clinical Officer	50%	25%	25%	-	-	-
Public Health Nurse	-	-	50%	-	50%	-
Registered Nurse	50%	-	50%	-	-	-
Enrolled Nurse						
/Midwife	32%	17%	21%	1.5%	9%	
5%						
Nursing Aide	17%	17%	66%	-	-	-
Research Institutions	-	25%	25%	25%	25%	-

1. Health education to the Community
2. Follow instructions/pesticides should have labels
3. Parents should keep pesticides away from children and foodstuffs.
4. Wear protective clothing
5. Use of non-chemical methods
6. Personal hygiene

**Discussion and conclusions**

The questionnaires were self-administered and answers to the the questions were self-reported and subjective. As such, they may have introduced some bias into the study. Educational backgrounds of the different cadres of health care workers was quite varied and this may have affected the responses.

The participation rate of 78.8% was satisfactory considering that these health-care workers were very busy as the health-care facilities were understaffed. There were slightly more female health-care workers than male which is usually the case as one goes from the big hospitals to the smaller rural health centres and dispensaries. Most of the physicians and clinical officers, usually male, were found in hospitals in the urban areas

within the study areas. It is evident that health care personnel in the rural areas are most often of lower cadre, with 77% of the Kenya enrolled nurses/midwife and 77% of the health-care personnel interviewed working in health centres and dispensaries, in rural areas.

The perception of health-care workers on whether pesticide poisoning was a problem and the gravity of this problem, was very low, with only 17% perceiving it to be a major problem.

The knowledge of the most important routes of pesticide entry into the human body was inaccurate as 68% mentioned ingestion and only 4.8% mentioned the dermal route of entry which is the most important in occupational exposure (Ambridge, 1988). It is important to note that 30% of the respondents had never seen a case of pesticide poisoning during their period of service in health-care and yet 5% had seen 10-70 cases that had come under their personal care. This indicates that pesticide poisoning can be a localised problem related to specific crop-protection practices and safe-use standards. Some health-care workers were not able to diagnose pesticide poisoning since the symptoms are similar to those of other common ailments in these areas, such as malaria.

The respondents indicated that there were many cases of pesticide poisoning that did not come to the attention of the health-care personnel and that most of these were among farm workers (24.5%). The reasons for these poisonings ranged from negligence (45%) to suicide (9%), lack of knowledge (3%) and the inability to follow instructions (1.5%).

Pesticide poisoning is difficult to manage and control without the know-how and the necessary drugs and equipment. Only 20% of the health-care workers reported that they were able and had the necessary means to treat pesticide poisoning. The rest had to improvise and this resulted in some rudimentary management practices.

It is, therefore, not surprising that almost all the health-care workers indicated that they would like to be provided with drugs and antidotes for the management and treatment of pesticide poisoning. In addition, they also reported that they required equipment for gastric lavage, intra-venous sets and nasogastric tubes. They also indicated that they would require information and training on the health aspects of pesticide exposure especially with regard to diagnosis, prescription and management of pesticide poisoning and the adverse effects of exposure to pesticides on human health.

With regard to advice and recommendations that health-care workers provide to farmers, it was found that 82% of the respondents were able to provide information on health aspects of pesticides. However, 30% of the information was directed at the community in general, 23% to patients who came to the health-care facilities for treatment and only 8% to the farmers. Half of the health-care workers (50%) gave information concerning issues of pesticide storage and handling while 14% was on first aid in case of pesticide poisoning. Only 3% of the respondents advised on instructions for use, another 3% on general awareness and health information. When asked for the most effective way of preventing pesticide poisoning, a relatively low proportion (33%) of the health-care workers recommended health education. Another 29% mentioned safe storage of pesticides, especially with regard to accidental/intentional pesticide poisoning, as the most effective prevention strategy.

Based on the results, we can conclude that all the different cadres of health-care workers need training to improve their perception of the gravity of pesticide poisoning in general, and occupational pesticide poisoning, in particular, in the communities they serve. In addition, it is necessary to start training programmes to improve the knowledge of HCWs so that, for instance, they know that the most important route of pesticide poisoning in occupational exposure is the dermal route. Also, in-service training in diagnosis, management (including First Aid), prevention and control of pesticide poisoning should be undertaken for all cadres of HCWs. This should be coupled with the provision of antidotes like atropine for the management of organophosphate pesticide poisoning, as well as equipment for gastric lavage and drip sets.

In fact HCWs should be trained to include the prevention and control of pesticide poisoning in their primary health-care programmes so that they can take this message to the people (rather than wait to teach them when they come to hospital as victims), as well as urge them to administer First aid in case of pesticide poisoning and seek treatment in conventional health-care facilities (dispensaries, health centres and hospitals as opposed to traditional medicine men). It is also necessary for HCWs to liaise with employers to improve the working conditions of their employees with respect to pesticide poisoning. It may also be necessary for HCWs, in collaboration with AEW to recommend to employers/farm owners the need to phase-out particular problem pesticides found to be hazardous because of their conditions of use in developing countries (for example, parathion and paraquat) as well as implement surveillance programmes for agricultural workers exposed to pesticides.



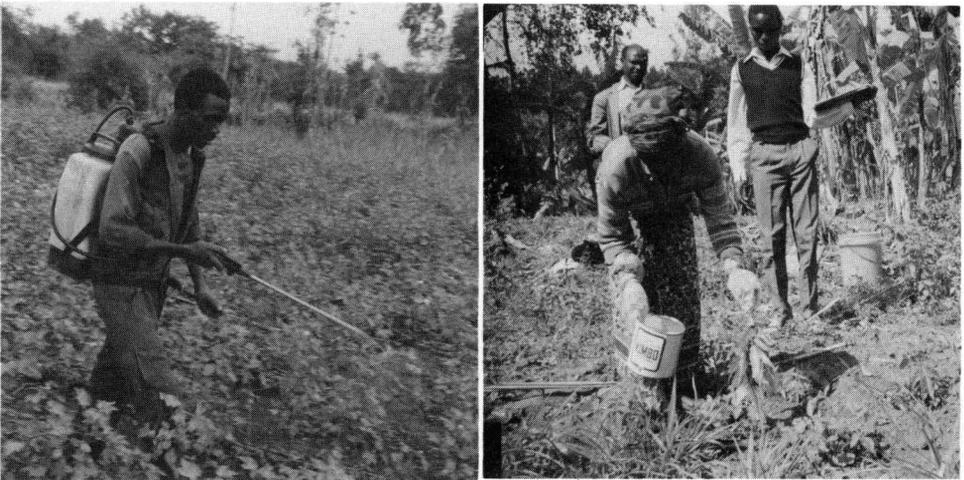
## **PART IV**

## **SYNTHESIS**



## Chapter 9

### General discussion



This discussion will focus on the study population being representative of agricultural workers in Kenya and organophosphates and carbamates being good markers of occupational pesticide exposure. Furthermore, acetylcholinesterase inhibition as an indicator of organophosphate and carbamate exposure will be discussed. This will be followed by a discussion on determinants of acetylcholinesterase inhibition and related symptoms. Finally, the results of the studies on knowledge, perceptions and behavioural practices among agricultural workers, agricultural extension workers and health care workers will also be discussed.

### **Study population**

A large number of farmworkers were recruited into the study after a comprehensive preparatory phase of the project. During this time, visits were made all over the country to identify areas where pesticides were being used in large quantities. The coffee crop in plantation agriculture was the initial target crop but had been neglected because of depressed global coffee prices and as a consequence, very little pesticides were being used. It was, therefore, decided that emphasis should be put on the flower industry for large-scale farming and cotton, tobacco and vegetables for small-scale farming. This decision was made on the basis of types and amounts of pesticides used, pesticide application equipment, personal protection and personal hygiene practices. In addition, care was taken to ensure that controls were also recruited from similar areas and comprised of people from more or less similar socio-economic backgrounds but who were unexposed. Almost all the controls from areas 2,3 and 4, were subsistence farmers. This resulted in more women among controls than among subjects because men were more often involved in the cash-crop agriculture while more women were involved in subsistence agriculture.

It is also to be emphasized that this was a voluntary exercise. Only willing farms and farmworkers participated. It was, therefore, not possible to determine the characteristics of farmworkers and farms that did not participate in the study. Most of the refusals were by large-scale farms which may have had higher exposure levels. They indicated that they were either too busy or were avoiding pirating of information on breeding, flower varieties and colours, which gave them an upper hand in the market place. Missing these

farms may have resulted in underestimation of exposure. Drop-outs after low exposure (initial phase) were mainly due to the invasive blood removal procedure, lack of monetary rewards, pregnancy and childbirth, illness and especially temporary employment. However, no statistically significant difference in age, was found between the workers who dropped out after initial recruitment and those who stayed on to the high exposure phase (Chapter 3). Furthermore, the subjects and controls had measurements performed during both low and high exposure periods.

The study areas selected were in different regions, districts and agri-ecological zones. The number of respondents varied from 666 farmworkers (chapter 3) to 539 (chapter 4) and 408 respondents (chapter 5), respectively. This was partly due to incomplete questionnaires or due to the requirements of the specific question being addressed. Chapter 6 dealt only with exposed individuals during high exposure ( $n=390$ ). Nevertheless, the resulting sub-populations are considered to be acceptable and representative. The representative sub-populations are assumed to have given unbiased estimates of the total population as it is unlikely that the above limitations affected the results. Of course, the main difficulties in achieving a representative sample are feasibility and costs. This is compounded by the fact that in developing countries, one has to conduct personal interviews because of lack of infrastructure (telephones) and there is sometimes the need to go back to the field, 200 to 500 km away to obtain missing information.

The selected agricultural extension workers and health care workers were assumed to be representative, especially because all workers within a 15 km radius had been recruited and the participation rates were high. The response rate of 72% for extension workers was quite good as they are usually *mobile* and may not be in a particular place when you need them to return the questionnaire or clarify certain issues. However, most of the extension workers had been in the area for quite a long time and knew the area and the farmworkers well. The participation rate of 78.8% for the health care workers was satisfactory considering that they were very busy as the health-care facilities were understaffed. The sample sizes of both groups were fairly small as only the extension and health care workers from around the study areas were interviewed. It was, therefore, not possible to make a distinction between the cadres during analysis.

### Exposure

Organophosphate and carbamate pesticides were used as markers for pesticide exposure because they are the major pesticide groups in common use in Kenya (Chapter 2; Mbakaya et al., 1994; Partow, 1995) and other developing countries like South Africa (London and Myers, 1995). Furthermore, cases of poisoning by these pesticides in developing countries are well documented (Jeyaratnam, 1985, 1987, 1990; Lopez-Carillo and Lopez-Cervantes, 1993; Mwanthi and Kimani, 1993; Keiffer et al, 1996; Kishi et al, 1995). In studies on mortality rates from pesticide poisoning, Mbakaya et al.(1994) attributed 90% of pesticide-related deaths in Kenya to organophosphate pesticides while London (1995) reported that organophosphates accounted for 75% of all pesticide poisonings in South Africa between 1990 and 1994. In fact, in the present study (Chapter 5), 61% of known pesticides used in area 1, 65% of those used in area 2 and 57% of those used in area 4 were cholinesterase inhibiting (organophosphate and mainly carbamates). In area 3, we don't know whether cholinesterase-inhibiting pesticides were used, as farmers reported using some "unknown" pesticides.

Organophosphates and N-methyl carbamate pesticides inhibit cholinesterase (Kaloyanova, 1982; Lopez-Carillo and Lopez-Cervantes, 1993) causing first, excitation and then depression of the parasympathetic nervous system (Miller and Shah, 1982). Exposure to organophosphate and carbamate pesticides was measured indirectly as acetylcholinesterase inhibition since it is an already proven method for biological monitoring using equipment that made possible repeated measurements in the field without need for sophisticated sample preparation methods. The field spectrophotometric method used, based upon the Ellman spectrophotometric method was relatively simple to use even by people with limited technical background, compared with laboratory methods such as the electrometric, colorimetric, titrimetric and tintometric methods used in laboratory determination of acetylcholinesterase (Coye et al., 1986). This method also precluded the need for transport and storage of samples, temperature control and problems of reagent preparation and storage which could have presented major logistic problems. The method was quite precise, with good reproducibility. To minimize the influence of variations in cholinesterase levels (Richter et al., 1986) on the interpretation of the test, individual pre-exposure values were obtained during the low exposure period as baseline data and could

be compared with later values for the same subject. Ames et. al (1989a, 1989b) have reported that in the absence of baseline cholinesterase measurements, interpretation of reported cholinesterase activity is difficult. Establishing a stable baseline requires a minimum of two pre-exposure tests taken at least three days but not more than fourteen days apart. If these tests differ by as much as 20%, a third sample should be taken and the two closest averaged and considered the true baseline (Extoxnet, 1993). In this study, the pre-exposure test for baseline was only done once as it had been confirmed during the preparatory phase that intra-individual differences were only about 10% (Ohayo-Mitoko et al. 1997a,..chapter 3).

The predictive value of using individual baseline levels versus laboratory or control group "normal values" was validated by Ames et al.(1989a, 1989b) who demonstrated that only 35% of those employees below threshold levels had tests in "normal" ranges. This shows that the method used in the study was a more sensitive method for cholinesterase determination than the laboratory methods.

It is usually recommended that in determining exposure to cholinesterase-inhibiting pesticides, both plasma (pseudo or butyrylcholinesterase) and red blood cell cholinesterase (acetylcholinesterase) should be measured. This is because some organophosphates and carbamates inhibit acetylcholinesterase faster and more intensely than pseudocholinesterase while the reverse is true for other cholinesterase-inhibiting pesticides. For instance, monocrotophos inhibits acetylcholinesterase much more than pseudocholinesterase (Van Sittert, 1991). In this study, erythrocyte cholinesterase (acetylcholinesterase) values were determined because it has been reported that erythrocyte rather than plasma values are recommended as the end point (Coye et al, 1986; Maroni et al., 1986, WHO, 1986). Plasma cholinesterase is only an indicator of exposure while erythrocyte cholinesterase is also an indicator of toxic effects and better reflects physiological effects on the nervous system (Coye et al., 1986). Acetylcholinesterase is also less affected by other health conditions than plasma cholinesterase, which is influenced by numerous factors other than pesticide exposure, including the general level of nutrition, liver damage, the use of foods containing xanthine (coffee, tea) and the use of drugs such as morphine, codeine chloroquine and thiamine (Ames et al., 1989a, 1989b; Wills, 1972). In addition, we

corrected for haemoglobin because Coye et al. (1986) have indicated that erythrocyte cholinesterase activity, which is measured per unit volume of whole blood, may be decreased in the presence of anaemia, if the measurement is not corrected for the haematocrit (haemoglobin). Our results, however, did not show such an effect.

As has been mentioned earlier, quantitative measurements of exposure were not performed. This would have shown the contribution of various routes of exposure and facilitated the eventual development of control strategies. Nevertheless, the effects of the internal body burden (Ohayo-Mitoko and Deneer, 1992) of these pesticides which is probably more important than external exposure as an indicator of health effects, was measured. The observations on patterns of mixing and application of pesticides was done at farm level but not at individual level, precluding the possibility of relating it to individual cholinesterase inhibition values and self-reported practices. Also, only sprayers had their cholinesterase levels determined. Although re-entry, supervision, pruning, harvesting, grading and packaging of flowers may influence exposure, these were overlooked, since mainly applicators were recruited into the study. In fact, babies carried on their mother's backs as the harvesting and grading tasks were performed may also have been at risk. This may be responsible for the lack of variability in determinants of acetylcholinesterase inhibition within areas. In addition, measurements to determine external exposure were not performed. Besides, most workers, especially on the large farms, but also increasingly on the small-scale farms lived on the farms together with their families. The farmers and their families are exposed by virtue of the fact that they live on the farm (environmental exposure). As stated by de Cock (1995), in situations where work environment and residential environment are closely connected, as is the case for some of the farms in this study, more attention should be paid to the contribution of residential and non-work related exposure. Loomis and Savitz (1994) observed that failure to include all exposure sources can bias results of epidemiological studies.

### *Factors influencing exposure*

Empirical modelling was applied to identify and quantify factors affecting exposure to cholinesterase-inhibiting pesticides. Insight into these factors might explain the differences in cholinesterase inhibition by area. Cholinesterase measurements were performed at the

end of the spraying operation so that variations in quantitative exposure during peak operations, for instance during mixing and loading, were not assessed separately. Besides, acetylcholinesterase levels change after occupational exposure of a few hours so that measurements at short intervals would, probably, not be useful. Assessment of external exposure could have been a method to address this issue.

Limitations of the models include the fact that we used self-reported data and could not test for reliability and validity using data from observations since observations were at farm level and could not be traced back to individual farmers during data management. In addition, there was no knowledge on real determinants as quantitative exposure assessment was not performed. Observations could not be used to assess the reliability and accuracy of the farmers' self-reported use of pesticides and other information as recommended by Blair and Zahm (1993). However, when self-reported data was checked against the observed practices, most of the answers were similar.

The models were adequate as they explained 57-70% of the observed variability in acetylcholinesterase levels. Results show that there were differences in possible determinants of cholinesterase inhibition between areas, especially with regard to the use of personal protective devices which were almost non-existent in areas 3 and 4. There was, however, no significant difference in hygienic behaviour between areas. WHO Class I pesticides were mainly found in area 1 while areas 2, 3 and 4 used minor amounts of these pesticides. Area 3 did not use any WHO class I pesticides at all. This may be because small scale farmers could not afford the high cost of class I pesticides and were not under pressure to produce a perfect crop as their products are mainly for local consumption. Furthermore, most of the farmworkers in areas 2, 3 and 4 performed both mixing and spraying tasks. In contrast, only about one third of the farmworkers in area 1 performed mixing tasks while about 65% performed spraying tasks only. Unfortunately, use of personal protective devices and hygienic behaviour was constant within areas. This is probably, because most of the subjects were sprayers (applicators) and tended to use the same type of personal protective devices had similar hygienic behaviour and sprayed the same type of pesticides within the same season. These phenomena limited the power of the statistical models to detect the effects of potential factors affecting exposure.

Despite a high percentage of use of personal protective devices in area 1 compared to areas 3 and 4, the reduction of acetylcholinesterase levels from baseline values was most pronounced in area 1. This may be possibly because these devices were either not properly used or soaked pesticide during spraying leading to more dermal exposure. The situation, however, could have been much worse in area 1 without the use of any protection at all. Also, the workers from area 1 were engaged full-time in pesticide applications, while the farmers in the other areas sprayed pesticides far less frequently. In addition, area 1 used very large amounts of pesticides and the largest amount of extremely hazardous pesticides (WHO Class 1), compared to the other areas. The statistical models could give no clarification with regard to this point. In area 1 most farmworkers wore boots, which were found to be protective when combined with an overall. Wearing boots solely appeared to lead to more inhibition, most likely because most clothing worn (other than some overalls) were made of cotton, leading to soaking of sprayed pesticides which consequently drained into the boots with a possibility of enhanced dermal uptake due to occlusion.

Access to a washing or bathing facility was found to have a preventive effect on depression of acetylcholinesterase levels. However, washing hands and bathing were found to be related to lower acetylcholinesterase levels possibly because the workers and farmers acted in a more reactive rather than proactive manner. It has also been shown that workers who sprayed WHO class 3 pesticides had a lower level of inhibition (5% less), than their counterparts who sprayed more toxic pesticides. The effects of spraying individual pesticides were rather inconclusive probably due to missing information and the spraying of mixtures. In area 1, spraying was to have a more profound effect on cholinesterase levels than mixing. Sprayers in this area did not perform other jobs and sprayed every day for long hours, exposing them to more pesticide than mixers.

### **Self-reported symptoms**

In chapter 5 levels of inhibition were related to reported symptoms to evaluate at which inhibition levels symptoms become elevated (Popendorf, 1990; Ames, 1989a, 1989b). Although Fillmore and Lessenger (1993) have reported that the signs and symptoms of mild poisoning can rarely be picked up on a physical examination, medical examinations

by a physician should have been incorporated into the study design to validate reported symptoms, especially in the more severe cases. This has been found to be of value even in cases of mild inhibition of acetylcholinesterase (>30%) and pseudocholinesterase (>40%) (Mullie and Abiola, 1997...in press). The elevated prevalence for some symptoms in both exposed and controls during the low exposure may have been caused by environmental factors. This was supported by the weaker clustering of these symptoms and the absence of a relationship between symptoms and acetylcholinesterase level for the low exposure period. The high dust levels during the hot dry period might explain some of the respiratory symptoms. Cooking indoors is an important determinant of indoor air pollution exposure in developing countries (Boleij et al., 1989). However, the change in symptom prevalence does not coincide with the likelihood of a high indoor air pollution exposure. The high prevalence of symptoms like irritability, forgetfulness, restlessness, and difficulties falling asleep could be explained by the high temperatures during this period. Symptoms in controls due to the high temperatures and environmental dust disappear during the high exposure period but remain in exposed workers because of organophosphate/carbamate exposure. This explanation is also supported by the observation that acetylcholinesterase inhibition and acetylcholinesterase level are normal in controls during the high and low exposure period but change considerably over time in exposed workers (Ohayo-Mitoko et al., 1997a, Chapter 3). This shows the value of measuring effects during both seasons for the subjects and controls as some of the changes may be attributable to environmental rather than occupational exposure.

The present study also suggests that an increased symptom prevalence might occur at acetylcholinesterase levels that are generally considered as non-adverse. It would be of benefit to include objective health parameters such as spirometric measurements and nerve conduction parameters in order to arrive at a health protective inhibition level probably below the present 30%, at which workers should be removed from exposure.

As mentioned earlier, most of the data used in chapters 5-8 were self-reported and subjective, which could introduce a strong information (responder) bias if the facts had been distorted by persons involved, including employers, either in hope of secondary gain or to avoid adverse outcomes, such as being fired or investigated by the authorities. Some

of the subjects consisted of groups from large farms and their input could reflect a psychogenic group consensus rather than the individual's unbiased assessment. Although independent information on the validity of the questionnaire items is not available, it seems unlikely that responder bias can explain the differences in symptom prevalence between exposed and control workers and the relationships between acetylcholinesterase inhibition and acetylcholinesterase level and symptoms. The relationships between symptoms and the potential confounders age and gender had the expected directions (increased prevalence for women and increasing prevalence with increasing age) and these relationships would also have been distorted when considerable responder bias would have been present. It is also possible that some of the relationships might have been confounded by the effects of smoking. Information about smoking habits was not available for both controls and exposed workers and correction for differences in smoking habits between exposed workers and controls was therefore not possible. This could especially have affected the relationships observed for respiratory symptoms. However, it is unlikely that differences in smoking habits can account for the large differences in respiratory symptom prevalence between controls and exposed during the high exposure period. Controls came from the same area as the exposed workers. The age distributions were similar as was the SES (measured as educational level). This makes the existence of large differences in smoking habits unlikely.

### **Self-reported knowledge, perceptions and practices**

Questions in relation to knowledge and practices were also self-reported. According to Blair and Zahm (1993), observations can be used to assess the actual reliability and accuracy of the farmers' self-reported use of pesticides and other information. However, since the observations took place at farm level, individual comparisons were not possible. Yet comparison between reported and observed practices showed similar patterns and, therefore, data can be seen as fairly reliable.

Males whenever present within the households, seemed to perform spraying duties. The agricultural workers from area 1 were particularly younger than the average agricultural worker interviewed, probably because this was the area with the highest number of workers employed by others since employers tend to go for the younger and more able

bodied males. It was also the only area with predominantly male pesticide applicators and the highest number of workers designated as sprayers. Women sprayers were found in areas 2, 3 and 4. Young age group, higher level of education and employment by others were found to be positive factors in the use of personal protective devices, personal hygiene practices and knowledge on important routes of pesticide poisoning.

Naivasha had better educated workers than the other areas. According to Mwanthi and Kimani (1993), the relationship between the level of education and the preparation of agrochemicals according to instructions was statistically significant. Similarly, the relationship between the level of education and use of personal protective devices while spraying the chemicals was found to be statistically significant. It has also been confirmed that low levels of education and training of the agricultural workforce make the workers particularly vulnerable to the risks of accidents and occupational diseases (Anon, 1992a). It is important for workers to be able to read the instructions on the pesticide labels as they often misinterpret pictograms, codes and symbols on containers (Tornuex, 1994; Sivayoganathan and Ramanabharathy, 1994). It was found that labelling and instructions were present on most pesticide containers. However, these were inadequate as they were mainly in English and did not have instructions for management in case of poisoning.

Most of the farms (95%) did not have an inventory for pesticides and so it was not possible to estimate the amounts and types of pesticides used annually. Some of the pesticides had been acquired illegally (smuggled) from neighbouring countries. This could also present problems for monitoring and surveillance of pesticide exposure. A well-kept inventory of pesticides used on a farm can be a useful tool for prevention and control of occupational pesticide poisoning as researchers and health-care workers would be able to relate types and amounts of pesticides used to symptoms seen or reported. In addition, it is to be emphasized that pesticide stores need to be properly ventilated, dry, protected from sunlight and heat, lockable and with the doors labelled for caution. There should be no danger of explosion or contamination of food, feed and water.

Mixing and loading of pesticides are generally known to be hazardous because of the high concentrations involved (Craig et al., 1993). However, because contact time was short

and also since most of the sprayers in area 1 did not mix pesticides, it was found to be less hazardous than spraying (especially for workers in area 1) which was sometimes carried out for 8 -10 hours. Mixing may be the major source of exposure for workers in areas 2, 3 and 4 since gloves were not used. Craig et al. (1993) demonstrated that a significant proportion of total exposure occurs on the hands during measuring and pouring small quantities of the concentrated pesticide product, causing more exposure than the spraying itself (Bonsall, 1985). In addition, mixing pesticide in domestic wares (buckets, saucepans etc) and run-off from spills into water sources could be a potential source of poisoning to the general public. Pesticide calibration was rarely carried out and the workers sometimes decanted hazardous pesticides using bottle tops leading to increased exposure. However, mixing in the knapsack or boomsprayer may have also contributed to less hazard seen for the mixers. During the observations, workers in the large-scale farms seemed to be more careful than the small-scale farms in mixing, spraying and cleaning of equipment.

Most of the farmers used leaking poorly maintained knapsacks and were walking through the sprayed foliage. In fact one should always spray while walking backwards so that they do not walk through the sprayed foliage, and do not spray pesticides on their colleagues. Also, some workers were seen to blow the nozzles of their knapsacks when blocked. Some of the spray machines, especially owned by small-scale farmers, were very basic hand-operated types, often having no proper nozzles. They were of inferior quality and often broke-down and leaked pesticide formulation onto the operator resulting in contaminated clothes throughout the day. These practices all led to increased exposure. Washing facilities were available but farmers tended to use them in a reactive rather than proactive manner.

Personal protective devices, as earlier mentioned were used more in area 1 than the other three areas. This is probably because they are generally too expensive for the small-scale farmer or the farmer does not know their benefits. Besides, most workers were not aware of the dangers posed by pesticides to their health. Observed personal hygiene practices were generally good in most areas. However, it was observed that they were generally worse than those reported. The workers in areas 2, 3 and 4 rarely washed their clothes

after spraying. They had less access to water on the farm. This could be disastrous in event of a major pesticide spill.

The large farms were more careful with the storage, assembly and cleaning of their equipment. In general, in three quarters of the farms, especially on the large farms, equipment were checked and assembled properly, and cleaned after use, sometimes with soap and water but most times with water only. A substantial number of small-scale farmers, especially from area 3 (Homa-bay), passed on the application equipment to the next farmer, unwashed, putting the receiving farmer at risk of contamination by a pesticide probably unknown to him.

Only area 1 disposed of its pesticide containers in a socially and environmentally acceptable manner. It was more likely for small-scale farmers, especially in areas 2 and 3 to re-use pesticide containers for storing food, feed or water for consumption by human beings and domestic animals than their counterparts in area 4. The pesticides supplied to area 4 from the tobacco company were usually in small containers and made of material that could generally not be re-used. Kitchen utensils were used in areas 2 and 3 to mix or apply pesticide and this could lead to poisoning.

The reported and observed practices with regard to the use and storage of pesticides and equipment as well as the use of personal protective devices and hygienic behaviour are quite often, far from safe. In order to bring about a reduction in pesticide exposure, a change in these practices is a necessity. To arrive at such change, knowledge is an important precondition. However, knowledge on important issues related to pesticide exposure was lacking in the group of agricultural workers, but also in the agricultural extension workers and the health care personnel. In particular, knowledge of routes of entry of pesticides into the body was inaccurate, the perceptions on the extent of the problem was negative and practices with regard to use, prevention and control of pesticide poisoning was poor. Knowledge on important routes of pesticide entry into the body (during occupational exposure) were largely inaccurate as inhalation rather than dermal route was considered to be the most important.

Pesticide poisoning is difficult to manage and control without the know-how and the necessary drugs and equipment. Only 20% of the health-care workers reported that they were able and had the necessary means to treat pesticide poisoning. The rest had to improvise and this resulted in some rudimentary management practices.

Almost all the health-care workers indicated that they would like to be provided with drugs and antidotes for the management and treatment of pesticide poisoning. In addition, they also reported that they required equipment for gastric lavage, intra-venous sets and nasogastric tubes. They also indicated that they would require information and training on the health aspects of pesticide exposure especially with regard to diagnosis, prescription and management of pesticide poisoning and the adverse effects of exposure to pesticides on human health. This indicates that there is much more than knowledge, perceptions and practices required in the diagnosis, management and prevention of pesticide poisoning. For instance, only a small fraction the health care workers, extension workers and farm workers mentioned the dermal route of entry as the most important in occupational exposure. This may be attributed to the fact that the health workers probably, most often, see suicidal cases. It is important to note that 30% of the health care workers had never seen a case of pesticide poisoning during their period of service in health-care and yet 5% had seen 10-70 cases who had come under their personal care. This indicates that pesticide poisoning can be a localised problem related to different crop-protection practices and safe-use standards. This can also mean that most health care workers did not recognize cases of pesticide poisoning or further, that the cases were always referred to the same persons. There was a disparity, by cadre, on the most effective way of preventing work-related pesticide poisoning. With regard to advise and recommendations provided to farmers, it was found that all the extension workers gave advise to the farmers on the use of pesticides and over 80% also gave advise on safe use. About 82% of the respondents were able to provide information on health aspects of pesticides. However, only 8% of this information was directed at farmers. A relatively low proportion (33%) of the health-care workers recommended health education as an effective way of preventing pesticide poisoning in the community while none of the extension workers mentioned health education. About one third of the health care workers mentioned safe storage of pesticides, especially with regard to accidental/intentional pesticide poisoning,

as the most effective prevention strategy. In contrast, extension workers stressed the use of personal protective devices. In addition, a majority of the health care workers did not know the first aid techniques for pesticide poisoning, yet they are usually based in rural locations far away from hospitals. It would be difficult to save lives without first aid.

There were slightly more female health-care workers than male which is usually the case as one goes from the larger hospitals to the smaller rural health centres and dispensaries. Most of the physicians and clinical officers, usually male, were found in hospitals in the urban areas within the study areas. It is evident that health care personnel in the rural areas are most often of lower cadre, with 77% of the Kenya enrolled nurses/midwife and 77% of the health-care personnel interviewed working in health centres and dispensaries, in rural areas. This is also true of extension workers.

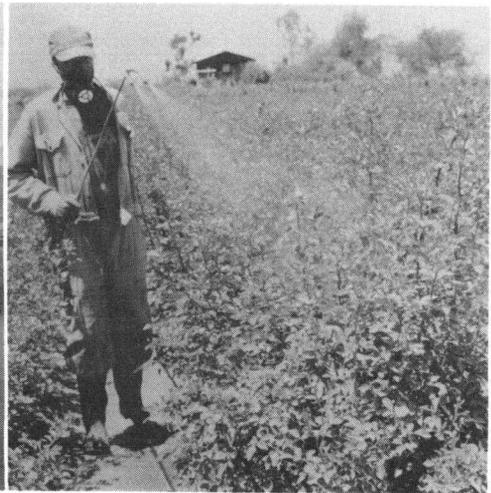
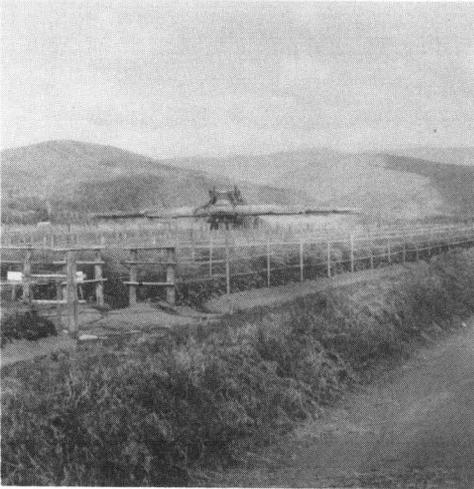
Perceptions on pesticides as a health hazard were found to be poor for farm workers as only one third perceived it to be a major problem. In fact, the situation was worse with health care workers and extension workers, with only a small percentage of the respondents perceiving pesticide exposure to be a major problem in the community.

This information derived from interviews and observations from a combination of groups is rather unique and together with the epidemiological findings, give a better opportunity to derive recommendations for strategies to solve the problem.



## Chapter 10

### Conclusions and recommendations



### General conclusions

This is the only comprehensive study to-date that has been carried out on occupational pesticide exposure among Kenyan agricultural farm workers. It gives a reliable picture of the population of agricultural workers from both small and large-scale farms in different regions of the country. In addition, it gives a complete picture of the types of pesticides and the crops on which they are used. This study has also determined the physiological effects of actual exposure, identified the factors responsible and the symptoms suffered as a result. Furthermore, knowledge, perception, and practice surveys were carried out for three groups of respondents; the agricultural workers, the agricultural extension workers and the health care workers. Results show that it is necessary to improve the deplorable situation and action is badly needed. As shown in the studies, the causes of pesticide poisoning are both environmental and behavioural.

*Environmental factors* are related to the system and are often beyond the control of the individual. They include:

- . the availability of "dangerous pesticides" (including WHO Ia and Ib)
- . availability of personal protective devices and engineering controls like enclosed mixing and loading systems or enclosed cabs, and industrial hygiene approaches
- . availability and accessibility of hospitals/dispensaries (health-care facilities)
- . availability of information on safe-use of pesticides, availability of water and facilities to wash/bathe on or near the farm and
- . availability of information and training on good agricultural practices such as integrated pest management (IPM).

In addition to environmental factors, *behavioral factors* are crucial and include:

- . compliance with safe-use instructions.
- . storage of pesticides, mixing and application practices
- . personal hygiene practices.

The overall objective of the study as well as the specific objectives, have largely been achieved.

## Recommendations

It is evident that greater emphasis should be placed on the occupational health of workers in the agricultural sector in developing countries. General recommendations are presented in the framework of the precede-proceed model for intervention (Green and Kreuter, 1991 see Annex 1). It consists of identifying the specific health-related behavioral and environmental factors that could be linked to the health problems deserving attention as well as policy, regulatory and organizational constructs.

Green and Kreuter (1991) describe the important determinants of behaviour in three broad groupings: predisposing, reinforcing and enabling factors. These factors are identified in order to arrive at adequate, policy, regulatory and organizational constructs.

### *Predisposing factors*

- . lack of knowledge at all levels and all parties involved
- . wrong beliefs
- . poor values and perceptions.

### *Reinforcing factors*

- . availability of personal protective devices
- . availability of supervision
- . availability of award schemes
- . availability of training

### *Enabling factors*

- . ability to use personal protective devices
- . possibility to obtain medical care for pesticide poisoning
- . possibility to obtain training on safe-use of pesticides
- . ability to read and follow instructions on safe-use
- . ability to use available water for personal hygiene
- . ability to utilize good agricultural practice systems such as IPM strategies

*Health education* is probably the most important intervention in the prevention and control of occupational pesticide poisoning. The lack of information which is experienced at all levels must be addressed through health education so that farmworkers, extension officers, health care workers and decision makers can make informed decisions with regard to safe management and use of pesticides. This education should be tailor-made for different categories and take into consideration major differences in age, knowledge and perceptions. It is also necessary for both extension and health care workers to be equipped with skills to conduct health education seminars and to disseminate new information as well as repeat old but important information.

*Policy* issues include:

- . revise, strengthen and enforce existing national and international legislation
- . enact new legislation whenever necessary
- . popularize good agricultural practices such as IPM and increase extension services to support them.

*Regulatory* issues include

- . pesticide importation and formulation
- . testing and registration of pesticides
- . ban extremely/highly hazardous pesticides
- . control smuggling across borders
- . train and certify users of hazardous pesticides

*Organizational* issues include:

- . accountability and self-regulation of providers of pesticides
- . product stewardship
- . safe-use, prevention and control programmes initiated and supported by the providers.

And finally, most importantly, *evaluation* should become an integral and continuous part of the interventions from the beginning.

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**It is necessary to urgently initiate interventions to address the gaps that were found. The results of this study will facilitate the development of effective multi-faceted strategies for management, prevention and control of occupational pesticide exposure in Kenya and other developing countries.**



### ***Recommendations for health promotion interventions***

The PRECEDE-PROCEED model for health promotion planning and evaluation (Green and Kreuter, 1991) has been used to formulate recommendations for interventions in this study. The **PRECEED** (*predisposing, reinforcing, and enabling constructs in educational/environmental diagnosis and evaluation*) framework takes into account the multiple factors that shape health status and helps the planner arrive at a highly focused subset of those factors as targets for intervention. PRECEDE also generates specific objectives and criteria for evaluation. The **PROCEED** (*policy, regulatory, and organizational constructs in educational and environmental development*) framework provides additional steps for developing policy and initiating the implementation and evaluation process. The identification of priorities and the setting of objectives in the PRECEDE phases provide the objects and criteria for policy, implementation and evaluation in the PROCEED phase (Green and Kreuter, 1991).

#### **Phase 1 (Social diagnosis - Quality of life).**

One begins with a consideration of quality of life by assessing some of the general hopes or problems of concern to the target population, in this case, the agricultural worker.

#### **Phase 2 (Epidemiological diagnosis)**

This phase is designed to identify the specific health goals or problems that may contribute to the social goals of problems noted in phase 1. Using available data, information generated by appropriate investigations, and epidemiological and medical findings, the planner ranks the health problems and sets priorities for educational and promotional programmes.

#### **Phase 3 (Behavioral and environmental diagnosis)**

This phase consists of identifying the specific health-related behavioral and environmental factors that could be linked to the health problems deserving attention. Because these are the risk factors that the intervention is tailored to affect, they must be very specifically identified and carefully ranked.

*Environmental* factors are those external to an individual, often beyond his or her personal control, that can be modified to support the behaviour, health or quality of life of that person or others affected by that person's actions.

#### **Phase 4 -Educational and organizational diagnosis**

Many factors could be identified that have the potential to influence a given health behaviour; these are the educational and organizational strategies likely to be employed in a health promotion programme to bring about behavioral and environmental change. The three broad groupings are predisposing, reinforcing and enabling factors.

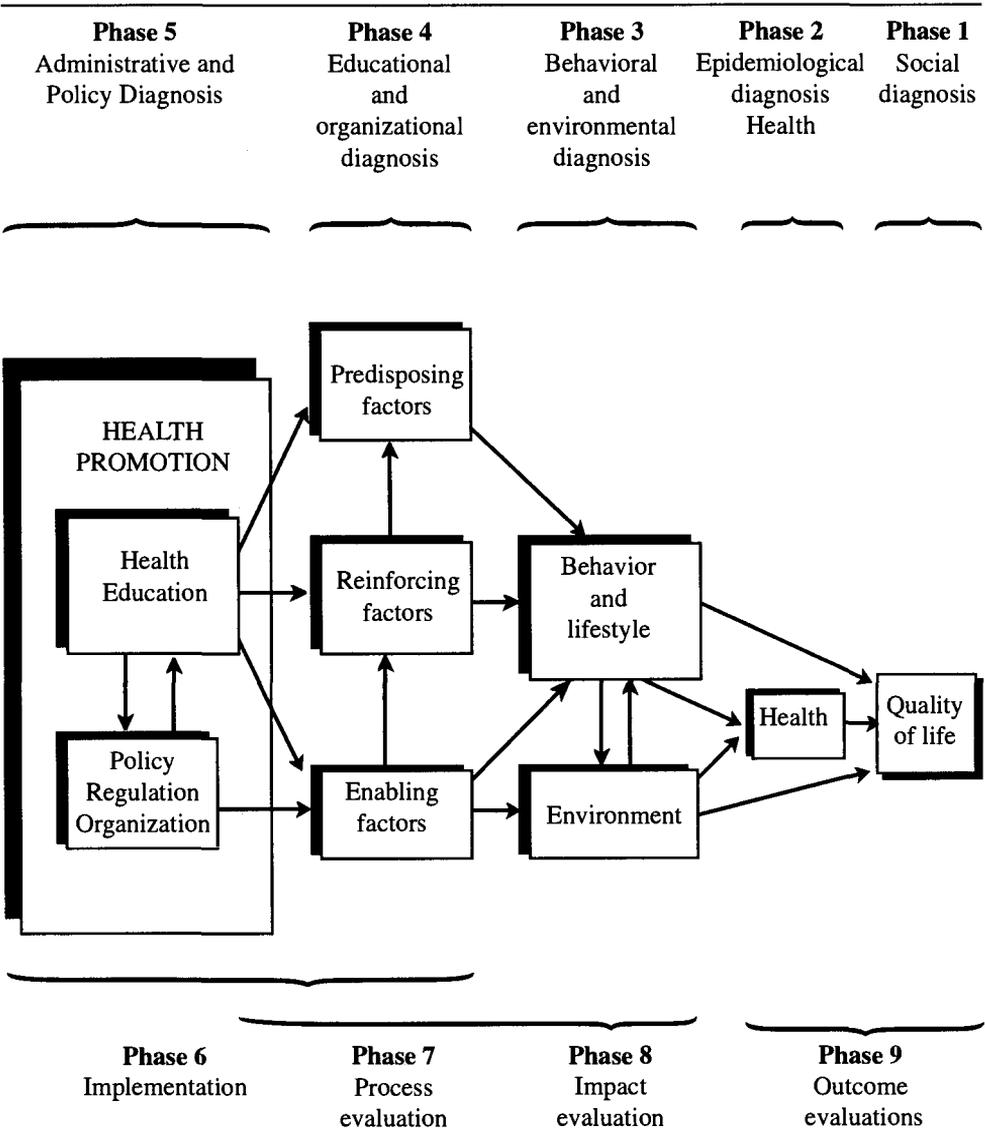
*Predisposing factors* include a person's or populations knowledge, attitudes, beliefs, values, perceptions that facilitate or hinder motivation for change. *Reinforcing factors* are the rewards received, and the feedback the learner receives from others following adoption of the behaviour, may encourage or discourage continuation of the behaviour. *Enabling factors* are the skills, resources, or barriers that can help or hinder the desired behavioral changes as well as environmental changes.

#### **Phase 5 - Administrative and Policy diagnosis**

This involves the assessment of organizational and administrative capabilities and resources for the development and implementation of a program. Limitation of resources, policies, and abilities and time constraints are assessed. This includes *Health education, policy, regulatory and organizational issues*.

All that remains after these five phases is the selection of the right combination of methods and strategies, the deployment of intervention staff, and the launching of the community organization or organizational development process. Evaluation becomes an integral and continuous part of working with the entire model from the beginning.

PRECEDE



PROCEED

Figure 10.1. The PRECEDE-PROCEED Model (Green and Kreuter, 1991).



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## Summary

Most developing countries do not monitor health effects, keep statistics or records of pesticide poisonings or incidents and information, even on importation and use of pesticides within a country is difficult to find. Pesticide importation records for 1989 - 1993 in Kenya are presented. The 370 formulations registered for use in Kenya by the Pest Control Products Board (PCPB), represent 217 active ingredients. Pesticides classified by WHO as highly hazardous (class I) accounted on average for around 22% of the volume imported while those classified as moderately hazardous comprised about 20%, and the less hazardous, 45% of the market. The rest of the imports were unclassified. A substantial proportion of the highly hazardous pesticides were imported as technical grade material, which means that, after local formulation, the ratio of highly hazardous to less hazardous pesticides was higher. Inorganic chemicals constituted the largest group of pesticides used in the country accounting for 21% of pesticide imports. They were followed by organophosphates (15%), organochlorines (11%), thiocarbamates (7%) and phthalimides (7%). Some pesticides that have been banned or severely restricted in other countries were still imported or smuggled into Kenya from neighbouring countries. The need for more reliable statistics and concerted efforts by all the key players in the regulation and control of the importation and use of pesticides is underscored.

The general objective of this project was to assess the health hazards posed by pesticide handling, storage and use on agricultural estates and small farms in selected communities in Kenya where cotton, tobacco and horticultural crops are grown with a view to developing strategies for the prevention and control of pesticide poisoning in Kenya and elsewhere.

The specific objectives were: to assess the intensity of absorption of selected pesticides through the use of biological monitoring techniques and the frequency of symptoms that may be attributable to pesticide absorption; to assess the knowledge, perceptions and reported practices of agricultural workers with respect to pesticide handling, storage and use, to observe and evaluate actual patterns of pesticide mixing, storage and application, as well as the use of personal protective devices, in order to identify the extent of potentially harmful pesticide handling practices; to assess the knowledge, perceptions and

reported practices of agricultural extension workers with respect to the safe handling and use of pesticides; to assess the knowledge, perceptions and reported practices of health-care workers with respect to the diagnosis, management (treatment) and prevention of pesticide poisoning and finally; to develop recommendations and guidelines with respect to the safe handling and use of pesticides for consideration by national implementation and regulatory agencies as well as the farmers and agricultural workers.

Study area 1 consisted of ten farms and estates, ranging in size from 100 to 3000 acres, in Naivasha Division of Nakuru District. The crops grown were flowers, French beans, strawberries, grapes and other horticultural crops mainly for export to Europe. The controls for this area were selected from one large sisal farm in Rongai Division of Nakuru District. This area belongs to the same agro-ecological zone as Area 1 and the agricultural workers on this sisal farm were comparable in socio-economic status to the subjects. Study area 2 included small-scale horticultural farmers from 14 sub-locations of Wundanyi Division in Taita-Taveta District as subjects and unexposed subsistence farmers from neighbouring farms as controls. The subjects practised intensive horticultural farming almost throughout the year to satisfy the demand for fresh horticultural products by the tourist industry in Mombasa. Study area 3 consisted of subsistence farmers from three sub-locations in West Karachuonyo Division of Homabay district. These farmers grew maize, beans, millet, sorghum and groundnuts during the long rains (February - July) and cotton as a cash crop during the short rains (September - October), to be harvested in December. There were also a few horticultural farmers along the shores of Lake Victoria who were recruited into the study because they used pesticides in the intensive cultivation of vegetables for sale to inhabitants of surrounding towns. Controls for this area were selected from unexposed subsistence farmers from within these three sub-locations. Study area 4 consisted of subsistence farmers in Central Migori location of Migori district who grew maize, beans, peas and vegetables without pesticides. In addition, they grew tobacco which was their main cash crop and used high concentrations of pesticides on relatively small plots (usually half-acre). Controls for this area were selected from subsistence farmers in Kabuoch 20 km away, who were not exposed to pesticides at all.

The agricultural extension workers (AEW) and health-care workers (HCW) were recruited from establishments within a 15 km radius of each study area.

Acetylcholinesterase inhibition was determined in 666 Kenyan agricultural workers. Out of these, 58.6% were mainly pesticide applicators and 41.4% unexposed controls from the four rural agricultural areas during 1993 and 1994. Acetylcholinesterase inhibition was found in all exposed individuals and led to an average in baseline acetylcholinesterase levels of 33%. The unexposed group had a non-significant decrease of only 4%. The exposed subjects in Naivasha (flower growers) had the largest inhibition (36%) followed by Homabay (cotton-growers) (35%) and Wundanyi (vegetable growers)(33%). Those in Migori (tobacco growers) had, by far, the least inhibition of acetylcholinesterase activity (26%). Acetylcholinesterase activity levels of 115 exposed individuals (29.6%) and no controls were depressed to values below 60% of baseline levels. The dramatic acetylcholinesterase inhibition observed can lead to chronic clinical and subclinical intoxication. There is, therefore, an urgent need for primary prevention programs to monitor and to address occupational exposures to these hazardous substances in agriculture in Kenya and other developing countries.

Empirical modelling techniques were used to identify and quantify factors affecting acetylcholinesterase activity levels in red blood cells (RBC) among agricultural workers in Kenya. The study was performed in four areas showing different shifts in acetylcholinesterase activity, which might be attributed to different crops sprayed, different application techniques, differences in personal hygiene practices (hygienic behaviour) and differences in access and use of personal protective devices and, of course, different types of pesticides used. The models were adequate as they explained 57-70% of the observed variability in acetylcholinesterase. Results show that there were considerable differences in possible determinants of cholinesterase inhibition between areas, especially with regard to personal protective devices which were almost non-existent in areas 3 and 4. There was, however, no significant difference in hygienic behaviour between areas. WHO Class I pesticides were mostly found in area 1 which also had the highest amounts and frequency of pesticide spraying, while areas 2 and 3 used minor amounts of these pesticides. Area 3, did not use any WHO Class I pesticides at all. Despite a high

percentage personal protective devices (ppd) use in area 1 compared to areas 3 and 4, there was a large reduction of acetylcholinesterase from baseline values. It is not clear whether this was as a result of ppds soaking pesticide, thereby, increasing dermal exposure or for some other reason. The situation, however, could possibly have been much worse without any ppd at all. In area 1, most workers wore boots, which were found to be protective only when combined with an overall; wearing of boots alone led to more inhibition. Access to a washing or bathing facility was found to have a positive effect on acetylcholinesterase levels. However, washing of hands and bathing seemed reactive rather than proactive; the workers washed and bathed immediately after or during the course of a spray shift as a result of spilling accidents or other contamination. Spraying was found to have a more profound effect on cholinesterase levels than mixing. It has also been shown that workers who sprayed WHO Class III pesticides had less inhibition (5%), than their counterparts who sprayed more toxic pesticides. Unfortunately, hardly any variability existed in factors such as ppd and hygienic behaviour within areas and this phenomenon limited the power of the statistical models to detect the effects of these potential factors affecting exposure.

The prevalence of reported symptoms was related to levels of inhibition. Complete data to study the relationship were available for only 256 exposed subjects (41.1%) and 152 controls (29.5%). Questions were asked on symptoms experienced at the time of interview, with a checklist of 42 symptoms. The results of a factor analysis *a posteriori* confirmed the existence of several clusters of symptoms identified *a priori*. The following clusters were obtained for further analysis: skin/extremities, respiratory, systemic, eye and central nervous system (CNS) symptoms. Of the symptoms in the cluster, a positive score on two or more was used as a cut-off point for further analysis, depending on the number of complaints in a cluster. The prevalence of symptoms was higher during the high exposure period than during the low exposure period in exposed subjects, although these differences were statistically non-significant. Interestingly, a clear and statistically significant decrease in symptoms prevalence was observed in the controls (Chi-square;  $p < 0.05$ ). The presence of a relationship between acetylcholinesterase inhibition, acetylcholinesterase level and respiratory, eye and CNS symptoms was established. Increased symptom prevalence was observed at acetylcholinesterase levels which are

generally considered as non-adverse. This relationship requires confirmation in an independent study using more objective health parameters.

The knowledge, perceptions, and observed and reported practices of agricultural workers, within the study areas, was assessed with respect to safe pesticide handling and use. A structured questionnaire was administered in English and translated orally to Swahili and the respective mother-tongues to 390 agricultural workers from the study areas. The Study group included males (92.8%) and females (8.2%) consisting of mainly sprayers, but also farmers, drivers of tractors and supervisors. The majority of agricultural workers interviewed were sprayers in Naivasha, and farmers in Wundanyi, Homabay and Migori. 68.5% had elementary education, 27.7%, secondary education while 3.3% had no education at all. Most of the respondents performed multiple jobs with 88.1% involved in spraying, 57.1% in mixing, 6% and 22.9% in the cleaning and repair of application equipment, respectively. None of the respondents reported obtaining their pesticides from the government; 63.1% obtained their pesticides from cooperative societies, 23.5% from stockists, 28.3% from a tobacco company, 4.9% from chemical companies while 3.9% was smuggled across national borders or bought from open-air markets. A large number of the respondents indicated that their pesticide suppliers gave them instructions on safe use; Naivasha (88.7%), Wundanyi (48.1%), Homabay (77.8%) and Migori (73.3%). When given three alternative ways in which pesticides could enter the human body during work, inhalation (85.4%) and dermal exposure (75.3%) registered high scores. Ingestion was given much less attention. However, 60% of the respondents did not know that the most important route of pesticide poisoning due to occupational exposure is the dermal route. About 81.3% of the decisions on the types and dosages of pesticides used were made by the supervisors/farm owners in Naivasha, 59.8% by the tobacco company in Migori whereas 97.5% and 94.4% of these decisions were made by the farmers and their families in Wundanyi and Homabay, respectively. 72.6% of the respondents reported that they stored pesticides. The rest (37.4%) did not store pesticides. 96% of the respondents in Naivasha, 43.2% in Wundanyi, 28.9% in Homabay and 45.6% in Migori stored pesticides in a pesticides store. Other forms of storage included "under the bed", in the bush and in the latrine etc. About 80% of the pesticides in storage on the farms were in their original containers, labelled and with mixing instructions and the containers were

closed tightly. There was almost no danger of fire or explosion as a result of pesticide storage on the farms visited. Most of the farms did not have an up-to-date inventory of supplies in the store or any records at all. About half of the "stores" were dry, well-ventilated, protected from sunlight and heat while only one third were locked-up and only 7.5% had doors labelled for caution. Mixing was sometimes done within the living house, especially on small-scale farms and on the farm in the case of large-scale farms. There was possibility of contamination of water sources in 26% of the farms, especially during mixing and spraying. 56.2% of the farms had mixing done in the knapsack, 33.6% in a bucket, then transferred into the knapsack, while the rest, mainly on the large farms mixed in the boom sprayers or tanks for hose-spraying. Infact, 92.5% of the equipment used on the farms surveyed were knapsack sprayers. Almost 90% of the respondents reported checking their equipment and assembling it properly before use and 73.3% washing and cleaning the equipment with soap and water after use. The rest, mainly small-scale farmers, either passed it on to the next farmer or stored dirty equipment or equipment with excess pesticide. Naivasha (93.3%) reported the highest number of agricultural workers who took precautions and wore personal protective devices when working with pesticides, and had more often a better combination of personal protective devices, followed by Wundanyi (46.9%) and Homabay (5.6%). None of the agricultural workers in Migori took precautions when working with pesticides. Similarly, 91.3% of the agricultural workers in Naivasha had a facility to wash/bathe, 92.7% washed/bathed after the use of pesticides and 96% changed their clothes right after work. While farmworkers employed by others scored the highest with regard to personal protective devices and personal hygiene, those employed by tenant farmers scored the lowest.

Obviously, there is an urgent need to implement training programmes to improve the knowledge, perceptions and practices of agricultural workers in Kenya with regard to safe use of pesticides.

Also, the knowledge, perceptions and practices of agricultural extension workers (AEW), within the study areas, was assessed with respect to the safe handling/use of pesticides. A structured self-administered questionnaire in English was distributed to 120 AEWs in the study areas. The participation rate was 72%. The study group included males (89.1%)

and females (10.9%) consisting of different cadres of agricultural extension workers; agricultural assistants (69.6%), agricultural officers (13%) and field assistants (17.4%). The duration of their service in agricultural extension varied from about 2 to 34 years with 75% of the respondents having worked for up to 15 years.

Results showed that 33% of the AEWs did not know the pesticide operations responsible for poisonings and only half of the respondents knew the potential hazards of the different pesticides used within their respective areas. Moreover, 68% of the AEWs perceived pesticide poisoning as a minor problem or not a problem at all. All the respondents reported that they had dealt with agricultural pesticides in the course of their work and had been involved in advising farmers on safe-use, with emphasis on following instructions on the labels, use of personal protective clothing/devices and personal hygiene, as well as proper storage in dry, locked-up stores with adequate ventilation, away from direct sunlight and away from the potential danger of fire or explosion. All the respondents were aware that pesticides could enter the human body during occupational exposure and 90% of them reported that they knew first aid procedures in case of pesticide poisoning. However, it was clear from the descriptions that the majority of them did not know the specific first aid procedures that are recommended for pesticide poisoning. Use of other methods of crop protection like integrated pest management (IPM) was mentioned by a negligible number of respondents (2.2%) but health education was not mentioned at all.

Finally, the knowledge, perceptions and practices of health-care workers (HCW) was assessed, with respect to diagnosis, management and prevention of pesticide poisoning. A structured self-administered questionnaire in English was distributed to 137 HCWs in the study areas. The participation rate was 78.8%. The study group included females (52.8%) and males (47.2%) consisting of different cadres of health-care workers; physicians (1.5%), clinical officers (4.5%), public health nurses (1.5%), Kenya registered nurses (6%), Kenya enrolled nurses/midwife (77%), Nursing aides (4.5%) and others, mainly public health technicians and clinical anaesthetists (5%), with a mean age of 32.4 range 21-52 years. All the physicians, clinical officers and 75% of the registered nurses were found in the hospitals whereas all the public health nurses and 45% of the enrolled

nurses/midwife were found in health centres. Results showed that the health-care personnel in rural areas were usually from the lower cadre, with 77% of the Kenya enrolled nurses/midwife and 77% of the health-care personnel interviewed working in health centres and dispensaries. The perception of health-care workers on whether pesticide poisoning was a problem and the gravity of this problem, was very low, with only 17% perceiving it to be a major problem.

The knowledge of the most important routes of pesticide entry into the human body in occupational exposure was poor and inaccurate as 68% mentioned ingestion and only 4.8% mentioned the dermal route of entry which is the most important in occupational exposure. It is important to note that 30% of all the respondents had never seen a case of pesticide poisoning during their period of service in health-care and yet 5% had seen 10-70 cases who had come under their personal care. This indicates that pesticide poisoning can be a localised problem that may occur in some rural areas and not others depending on their crop-protection practices and safe-use standards.

Pesticide poisoning is difficult to manage and control without the know-how and the necessary drugs and equipment. Only 20% of the health-care workers reported that they were able and had the necessary means to treat pesticide poisoning. The rest had to improvise and this resulted in some rudimentary pesticide management practices. With regard to advice and recommendations that health-care workers provide to farmers, it was found that 82% of the respondents were able to provide information on health aspects of pesticides. However, 30% of the information was directed to the community in general, 23% to patients who came to the health-care facilities and only 8% to the farmers. 50% of the health-care workers gave information concerning issues of pesticide storage and handling while 14% was on first aid in case of pesticide poisoning. Only 3% of the respondents gave advice on instructions for use, another 3% on general awareness and health information.

The respondents indicated that there were many cases of pesticide poisoning that did not come to the attention of the health-care personnel and that most of these were among farmworkers (24.5%), and the reasons for this ranged from negligence (45%) to suicide

(9%), lack of knowledge (3%) and the inability to follow instructions (1.5%). Almost all the health-care workers indicated that they would like to be provided with drugs and antidotes for the management and treatment of pesticide poisoning. In addition, they also reported that they required equipment for gastric lavage, intra-venous sets and nasogastric tubes. They also indicated that they would require information and training on the health aspects of pesticide exposure especially with regard to diagnosis, prescription and management of pesticide poisoning and the effects of exposure to pesticides on human health. A relatively low proportion (33%) of the health-care workers recommended that the most effective way of preventing pesticide poisoning in the community would be through health education. Another 29% mentioned safe storage of pesticides, especially with regard to accidental/intentional pesticide poisoning, as the most effective prevention strategy.

This is the only comprehensive study to-date that has been carried out on occupational pesticide exposure among Kenyan agricultural farm workers. It gives a reliable picture of occupational pesticide exposure in the population of agricultural workers from both small and large-scale farms in different regions of the country. In addition, it gives a complete picture of the types of pesticides and the crops on which they are used. This study has also determined the physiological effects of actual exposure, identified the factors responsible and the symptoms suffered as a result. Furthermore, knowledge, perception, and practice surveys were carried out for three groups of respondents; the agricultural workers, the agricultural extension workers and the health care workers. Results show that it is necessary to improve the deplorable situation and action is badly needed and as shown in the studies, the causes of pesticide poisoning are both environmental and behavioural. The overall objective of the study as well as the specific objectives have largely been achieved.

It is evident that greater emphasis should be placed on the occupational health of workers in the agricultural sector in developing countries. General recommendations for interventions, include identifying the specific health-related behavioural and environmental factors that could be linked to the health problems deserving attention. Results of this study have identified these gaps as well as policy, regulatory and organizational issues. **It is now**

necessary to urgently initiate interventions to address the gaps that were found. The results of this study will facilitate the development of effective multi-faceted strategies for management, prevention and control of occupational pesticide exposure in Kenya and other developing countries.



## MUHTASARI

Nchi zinazoendelea aghalabu hazifuatili madhara ya kiafya, hazitunzi takwimu au taarifa za vifo na matukio ya kudhurika na sumu kutokana na vijasumu (pesticide), hata habari juu ya uagizaji na matumizi ya vijasumu ndani ya nchi ni vigumu kupatikana taarifa za uagizaji wa vijasumu nchini Kenya kati ya mwaka 1989-1993 inaonyesha yafuatayo. Michanganyiko (formulations) 370 imethibitishwa kwa matumizi nchini Kenya na Bodi ya Kusimamia Vijasumu (Pest Control Products Boards, PCPB), michanganyiko hiyo imetengenezwa kwa kutumia vichanganyiko vyenye kufanya kazi (active ingredient) 217. Shirika la Afya Dunia (WHO) limeainisha viasumu vinavyoagizwa nchini Kenya ifuatavyo asilimia 22 ya vijasumu vyote, ni vile vinavyoelekea kuwa vyenye hatari sana, wakati huo huo asilimia 20 ya vijasumu vimeainishwa kuwa na hatari ya wastani, kiasi cha asilimia 45 ya vijasumu vinavyouzwa kwenye soko vimeainishwa kutokuwa au kuwa na madhara kidogo. Asilimia iliyobaki ya vijasumu vinavyoagizwa haikuainishwa.

Sehemu kubwa ya vijasumu vyenye katari sana vinaagizwa nje kama mada ya daraja la juu, hii ina maana kwamba, baada ya kufanya michanganyiko nchini, vijasumu vilivyoainishwa kuwa ni hatari sana ukilinganisha na ile yenye vijasumu vinavyoainishwasi kuwa si vya hatari ilikuwa si kubwa. Kemikali zenye asili ya mawe huchangia kiasi kikubwa cha vijasumu vinavyotumika nchini zikiwakihisha asilimia 21 vijasumu vyote vinavyoagizwa nchini. Kemikali hizi zinafuatiwa na zile zenye asili ya mimea na fosfati (15%), zenye asili ya mimea na kloline (11%), zenye asili ya salfa (7%). Baadhi ya vijasumu ambavyo vimekatazwa kabisa au kutumika kwa masharti maalum katika nchi nyinginge bado vinaagizwa au kuingizwa kwa siri nchini Kenya kutoka nchi za jirani. Haya ya kuwa na takwimu sahihi na hatua za pamoja kati ya wahusika wote wanashughulikia kurekebisha na kuzuia waagizaji na matumizi ya vijasumu inasisitizwa.

Kwa ujumla lengo la mradi huu lilikuwa kukadiria madhara ya kiafya yaletwayo na kushika, kutunza na matumizi ya vijasumu katika mashamba makubwa na vishamba vidogo katika jamii zilizochaguliwa nchini Kenya mahali ambapo pamba, tumbaku na mazao ya matunda yanalimwa. lengo lilikuwa kuandaa mkakati wa kuzuia na kuthibiti athari za sumu nchini Kenya na shemu nyingine.

Malengo dhahiri ya mradi yalikuwa: kukadiria nguvu za kumezwa kwa vijasumu vilivyochaguliwa kupitia kwa matumizi ya teknolojia ya kuhakiki kibiologia na kadiri ya alama zinazoonyesha uwezekano wa kumezwa kwa sumu, kukadiria maarifa, mtazamo na taarifa za kazi za wafanyakazi wa kilimo hususani kuhusu kushika, kutunza na matumizi, kuchunguza na kukadiria mifumo ya kuchanganya, kutunza na kutumia vijasumu, pia kuangalia matumizi na vifaa vya kujikinga, vile vile matumizi ya vifaa binafsi vya kujikinga, ili kuthibitisha kuenea kwa uwezekanowa njia mbovu za matumizi ya vijasumu, kukadiria maarifa; mtazamo na taarifa za habari kuhusu utendaji wa mabwana shamba hususani juu ya njia salama za kushika na matumizi ya vijasumu, kukadiria maarifa, mtazamo na taarifa za habari kuhusu mabwana afya hususani jinsi ya kupima, kutibu na kuzuia vifo vitokanavyo na sumu na mwisho, kutoa mapendekezo na mwongozo hususani ni juu ya njia aslama za kushika na kutumia vijasumu ili zipekelwe mbele ya taifa kwa utekelezaji, kwa wakala za nurekebisha pia kwa wakulima na wafanyakazi wa kilimo.

Eneo la utafiti 1 lilihusu mashamba kumi madogo na mashamba makubwa yenye eneo kuanzia ekari 100 hadi 3000 katika tarafa ya Naivasha katika wilaya ya Nakuru. Mazao yanayolimwa ni pamoja na maua, maharagwe, strawberries, zabibu na mazao mengine ya matunda zaidi kwa ajili ya kusafirishwa Ulaya. Eneo la kulinganishia lilichaguliwa kutoka katika shamba kubwa la mkonge katika tarafa ya Rongai wilayani Nakuru. Eneo hili linafanana katika udongo na klimati na lile la kwanza lililotajwa hapo juu, na wafanyakazi wa kilimo katika shamba la mkonge wanawezakulinganishwa katika nafasi zao katika jamii kiuchumi hususani ni juu ya utafiti uliokuwa ukiendelea. Eneo la pili la utafiti lilihusu wakulima wenye mashamba madogo ya matunda kutoka vitongoji 14 katika tarafa ya Wundanyi katika wilaya ya Taita-Tareta kama walengwa na wakulima wakawaida wadogo wasiotumia kemikali kama mashamba ya kulinganishia. Walengwa hawa wanashiriki kilimo cha matunda cha hali ya juu mwaka mzima ili kutosheleza mahitaji ya matunda na mazao yake kwa mji wa kitalii wa Mombasa. Eneo la 3 la utafiti lilihusu wakulima wadogo wadogo kutoka vitongoji vitatu katika tarafa ya Karachuonyo magharibi katika wilaya ya Hombay. Wakulima wa hapa hulima mahindi, maharagwe, ulezi, mtama na karanga wakati wa masika (February-July) na pamba kama zao la biashara wakati wa vuli (September-October), ambayo huvunwa Desemba. Walikuwepo pia wakulima wachache wa matunda kwenye mwambao wa Ziwa Victoria ambao walishirikishwa katika

eneo la utafiti hili kwa sababu ya kutumia kwao vijasumu katika kilimo chao cha hali ya juu cha matunda kwa ajili ya kuuza kwa wananchi wa miji iliyowazunguka. Eneo la kulinganishia na hawa lilichaguliwa kutokea kwa wakulima wadogo wasiotumia kemikali ndani ya vitongoji vitatu hivi. Eneo la 4 la utafiti lilihusu wakulima wadogo kutoka Migori Kati katika wilaya ya Migori ambao hulima mahindi maharagwe, njegere na mboga bila kutumia kemikali. Zaidi ya hayo, wanalima tumbaku, ambayo ni zao lao la biashara na hutumia kemikali kali katika maeneo ya viploti vidogo (kama nusu heka). Eneo la kulinganishia na hili lililotajwa hapo juulilichaguliwa kutoka kwa wakulima wadogo huko Kabuoch kama kilometa 20, kutoka kwa wakulima ambao hawakuwa na matumizi ya kemikali kabisa.

Mabwana shamba na mabwana afya walioshiriki waliteuliwa kutoka taasisi mbali mbali ndani ya kilometa 15 nusu kipenyo cha eneo la utafiti ukandamizaji wa kazi za enzaimu (acetylcholinesterase) ulipimwa kati ya wafanyakazi 666 wa kilimo nchini Kenya. Kati ya hao, asilimia 58.6 walikuwa ni watumiaji wa kemikali na asilimia 41.1 walikuwa hawatumii kabisa kemikali kutoka sehemu nne za wakulima wadogo kati ya mwaka 1993 na 1994. Ukandamizaji wa kazi wa enzaimu (acetylcholinesterase) ulionekana kati ya watu wote waliotumia kemikali na hii ilipeleka kupunguka kwa kiwango cha enzaimu (acetylcholinesterase) hadi asilimia 33. Kikundi cha walengwa kisichohusika na matumizi ya kemikali hakikuonyesha upungufu wa kutosha wa enzaimu, ni asilimia 4 tu ilioonyesha upungufu wa enzaimu hiyo. Walengwa watumiaji wa kemikali katika wilaya ya Naivasha (walima maua) walionyesha ukandamizaji mkubwa wa kazi ya enzaimu (36%) walifuatia wakulima wa pamba toka Homabay (35%) na wakulima wa mboga wa Wundanyi (33%). Wakulima wa tumbaku kutoka Migori, walionyesha kiwango cha chini kabisa cha ukandamizaji wa kazi za enzaimu (acetylcholinesterase) (26%). Viwango vya utendaji wa enzaimu (acetylcholinesterase) watu 115 waliotumia kemikali (29.6%) na hakuna watu katika maeneo ya ulinganifu (wasiotumia kemikali) walioonyesha ukandamizaji wa enzaimu chini ya kiwango cha asilimia 60% ya kiwango kinachokubaliwa. Jambo la kushangaza ni kwamba ukandamizaji wa kazi za enzaimu (acetylcholinesterase) uliojionyesha unaweza ukapelekea kwenye matatizo ya kudumu ya kihospitali na matatizo ya kati ya kulewa au kurukwa na akili. Kwa hiyo, kuna hitajika haraka programu za kuzuia, na kufuatilia na kujihusisha na walengwa watumiaji wa kemikali hizi za hatari katika kilimo

katika nchi ya Kenya nchi nyingine zinazoendelea. Teknolojia ya matumizi ya modeli zinazobahatisha ilitumika kuthibitisha na kukadiria sababu zinazotawala viwango vya kazi vya enzaimu (acetylcholinesterase) katika chembe chembe nyekundu za damu kati ya wafanyakazi wa kilimo nchini Kenya. Utafiti ulifanyika katika sehemu nne ukionyesha mabadiliko mbali mbali katika uwezo wa kazi wa enzaimu, hii inawezakuchangiwa na utofauti wa mazao yahiyo nyunyiziwa kemikali, tofauti ya teknolojia katika kunyunyizia, tofauti za watu hujali usafi kazini na upatikanaji na matumizi ya vifaa mbali mbali vya kujikinga na kemikali. Modeli zilizotumika zilikuwa sahihi kiasi cha kutosha kwani zinaelezea asilimini 57-70% ya kigeugeu kilichoonyeshwa na enzaimu. Matokeo haya yanaonyesha kuwa kulikuwa na tofauti za kutosha katika njia za kupima ukandamizaji wa kazi za enzaimu kati ya eneo na eneo, na zaidi kuhusu njia za binafsi na vifaa kujikinga na kemikali ambavyo ni kama havikuweco kabisa katika maeneo ya utafiti namba 3 na 4. Hata hivyo hazikuonekana tofauti kubwa za usafi kati ya walengwa katika maeneo ya utafiti. Kemikali kali zilizoainishwa kuwa ni za hatari sana, kufuatana na Shirika la Afya la Umoja wa Mataifa ziliguunduliwa katika eneo namba 1, eneo ambalo liliambatana na unyunyizaji wa mara nyingi, wakati maeneo namba 2 na 3 yaligundulika kutumia kiasi kidogo cha kemikali. Eneo namba 3 halikuonyesha kutumia aina yoyote ya kemikali kame ilivyoainishwa na shikirika la Afya la Umoja wa Mataifa. Pamoja na asilimia kubwa ya matumizi ya njia na vifaa vya kujikinga na kemikali katika eneo namba 1 ukilinganisha na maeneo namba 3 na 4, kuligundulika upungufu mkubwa wa kiasi cha enzaimu ukilinganisha na kiwango kinachokubaliwa kwa wazi kama hali ya namna hii imetokana na njia na vifaa vya kujikinga kunyonya kemikali hivyo kuongeza uwezekano wangozi kushambuliwa au sababu nyingivezo zinahusika. Pamoja na hayo, hali ya walengwa ingekuwa mbaya zaidi kama kusingekuwepo njia na vifaa vyovyote vya kujikinga. Katika eneo namba 1, wafanyakazi wengi huvaa mabuti, ambayo uwezo wake wa kumkinga mhusika unakuwa na maana yanapoongezewa ovaroli; kuvaa buti pekee kunapelekea kuongeza ukandamizaji wa enzaimu. Awezo wa kuwa na vifaa vya kunawa au kuoga ulionyesha kusaidia kuongeza viwango vya enzaimu. Walakini kunawa mikono na kuoga kulionekana matokeo ya kumwagiwa sumu zaidi ya kujikinga sumu wafanyakazi kunawa na kuoga mara tu au wakati wa zamu za kunyunyuzia kwa sababu ya nasibu ya kumwagikiwa au kugusa enzaimu. Unyunyizaji ulionekana kwenda chini zaidi kwa kutumia viwango vya cholinesterase zaidi ya kuchanganya. Imekuwa ikuonyesha kuwa wafanyakazi ambao

wamenyunyuzia ainisho la WHO daraja III la vijasumu (pesticides) kumepunguza ukandamizaji wa enzaimu kwa asilimia 5 zaidi uwezao ambao wamenyunyuzia vijasumu zenye sumu zaidi. Kwa bahati mbaya, kila tofauti iliyokuwepo mara chache ilitokana na vigezo kama PPD na tabia ya usafi katika maeneo na hali hii ilizuia uwezo wa vielelezo vya takwimu kugundua matokeo ya vigezo ambavyo si vya wazi vinavyoleta madhara ya watumiaji.

Kwa kawaida ya taarifa za dalili za magonjwa zilizotolewa ziliwianishwa na viwango vya ukandamizaji. Mambo kamili ya uhakika kwa utafiti wa uhusiano uliopo yalikuwepo kwa masomo 256 tu yaliyofundishwa (41.1%) na 152 ya kulinganisha (29.5%). Maswali yaliulizwa juu ya dalili za magonjwa zinazoonekana wakati wa usaili pamoja na orodha ya kukakiki dalili za magonjwa 42. Matokeo ya mchanganyo wa vigezo baadaye ulithibitisha kuwepo kwa makundi ya dalili za magonjwa mbali mbali yaliyotambuliwa mwanzoni (priori). Makundi yafuatayo yalichukuliwa kwa mchangano zaidi: ngozi/extremities, respiratory, systematic, macho na mfumo mkuu wa fahamu (CNS). Dalili za magonjwa katika kundi, uhakika wa alama mbili au zaidi zilitumika kumaliza mchangano, kutegemea na idadi walalamikaji katika ugonjwa. Mazoea ya dalili za magonjwa kuwa juu zaidi katika kipindi cha kutumia sana kuliko wakati wa kipindi cha kutumia kidogo imejonyesha katika masomo, ijapokuwa hizi tofauti kitakwimu hazina umuhimu. Cha kuvutia, mabadiliko ya wazi ya takwimu katika dalili za magonjwa ya kawaida yalionekana katika kulinganishwa (controls) (chi-square,  $p < 0.05$ ) ukusiano uliopo kati ya ukandamizaji wa acetylcholinesterase na respileisheni, macho na mfumo mkuu wa ufahamu (CNS) ulithibitishwa. Kuongezeka kwa dalili za ugonjwa kuenea kulionekana kwenye kiwango cha acetylcholinesterase ambacho kwa ujumla kinachukuliwa kama kisicho na madhera. Huu usiano unahitaji uthibitishwo katika utafiti wa pekee kwa kutumia zaidi vigezo halisi vya kiafya.

Maarifa, mtazamo na uchunguzi na wakulima katika maeneo ya utafiti, iliokadiriwa ya vijasumu orodha ya maswali katika kingereza na kutafsiriwa kwa kiswahili na kwa lugha za kwao 390 za kundi la kujifunzia linakuwa na wanawume (92.8%) na wanawake (8.2%) na linakuwa namabomba ya kunyunyuzia zaidi, lakini pia wakulima, madereva wa matrekta pamoja na wasimamizi. Wafanyakazi wa kilimo wengi waliosailiwa walikuwa

wanyunyuziaji wa madawa wa Naivasha na wakulima wa Wundanyi, Homabay na Migori.

Asilimia 68.5 walikuwa na elimu ya msingi, asimilia 27.7 elimu ya sekondari wakati asilimia 3.3 hawakuwa na elimu kabisa. Wengi waliitikia walifanya kazi nyingi asilimia 88.1 wao walijihusisha kwenye kunyunyuzia, asilimia 57% katika kuchanganya, asilimia 6 na asilimia 22.9 kusafisha na kutengeneza zana zilizoharibika baada ya kutumiwa. Hakuna hata mtumiaji wa madawa ya vijasumu aliyepata madawa hayo serikalini; asilimia 63.1 walipata vijasumu kutoka vyama vya ushirika. Asilimia 23.5 kutoka wauzaji binafsi, 28.3 kutoka shirika la tumbaku, asilimia 4.9 kutoka mashirika ya madawa wakati asilimia 3.9 zilizoingizwa nchini kwa magendo au zilinunuliwa kutoka gulio. Namba kubwa ya watumiaji walionyesha kuwa watoaji wao wa madawa ya vijasumu waliwapa maelekezo juu ya matumizi salama: Naivasha (88.7%), Wundanya (48.1%), Homabay (77.8%) na Migori (73.3%). Wakati walipotoa njia tatu kwazo vijasumu zingeweza kuingia katika mwili wa mwanadamu wakati wa kutumia, kwa kuvuta pumzi ni asilimia 85.4 na kupitia kwenye ngozi ni asilimia 75.3 hizi ziloonyesha kuchukua nafasi ya juu. Uingizaji tumboni kulipewa umuhimu kidogo walakini asilimi 60 ya watumiaji hawakujua njia muhimu ya kujizuia na vijasumu wakati wa kutumia kuwa ni kupitia kwenye ngozi (dermal route). Kama kiasi cha asilimia 81.3 ya maamuzi ya aina na kiasi cha dawa za vijasumu kilichotumika kilibuniwa na wasimamizi/wenye mashamba wa Naivasha, asilimia 59.8 na shirika la tumbaku huko Migori wakati kwa upande mwingine asilimia 97.5 na asilimia 94.4 ya maamuzi haya yalifanywa na wakulima na jamaa zao huko Wundanyi na Homabay (Wundanyi (97.5%), na Homabay (94.4%)). Asilimia 72.6% ya watumiaji wali taarifu kuwa wametunza vijasumu. Waliobaki (37.4%) hawakutunza vijasumu. Asilimia 96 ya watumiaji huko Naivasha walitunza vijasumu katika ghala za vijasumu, asimilia 43.2 huko Wundanyi, asilimia 28.9 huko Homabay na asilimia 45.6 huko Migori. Aina nyingine ya utunzaji ni pamoja na uvunguni, kwenye vichaka, chooni n.k. Kiasi cha asilimia 80 ya vijasumu zilihifadhiwa zilikuwa katika vyombo vyao vya asili vya kuhifadhi, zikiwa na vipande vya makaratasi vyenye maelekezo jinsi ya kuchanganya na vyombo hivyo vya kuhifadhiwa vilikuwa vimefungwa sana. Hapa kuwa na fursa ya hatari ya moto au kulipuka katika mashamba yaliyotembelewa kwa sababu ya kuhifadhi vijasumu. Mashamba mengi haya kuwa na hati ya kumbukumbu ya vitu vilivyoingia kwenye ghala au kumbukumbu zozote. Kiasi cha nusu ya ghala zilikuwa kavu, zilikuwa

zinapitisha hewa vizuri, zimekingwa kwa mionzi ya jua na moto wakati moja ya tatu tu ilikuwa na milango yenye vipande vya karatasi yanayo tahadharisha. Kuchanganya wakati mwingine kulifanyika ndani ya nyumba ya kuishi, hasa kwenye mashamba madogo na kwa upande wa mashamba makubwa uchanganyaji ulifanyikia shambani. Kulikuwa na uwezekano wa kuchafua vyanzo vya maji kwa asilimia 26 ya mashamba, hasa wale watu wa huchanganya na kunyunyizia. Asilimia 56.2 ya mashamba uchanganyaji ulifanyika ndani ya mkoba, asilimia 33.6 ndani ya ndoo halafuikahamishwa ndani ya mkoba, wakati uchanganyaji uliobaki hasa kwenye mashamba makubwa. Uchanganyaji ulifanyika kwenye 'boom sprayers' au kwenye vyombo vikubwa (tanks) kwa unyunyizi wa kutumia bomba la mpira (hose spraying). Kwa ujumla, asilimia 92.5 ya zana zilizotumika kwenye mashamba yaliyochunguzwa zilikuwa 'knapsack sprayers'. Karibu asilimia 90 ya watumiaji ilijalika kuwa wanatazama zana ili kujua kama ziko sawa na kuweka sehemu zake sawa sawa kabla ya kutumia na asilimia 73.3 walikuwa wanaosha na kusafisha zana kwa sabuni na maji baada ya kuzitumia. Waliobaki, hasa wakulima wadogo wadogo, ama mkulima anayefuata alizitumia au waliweka zana chafu au waliziweka zana zilikuwa na vijusumu kupita kiasi. Naivasha (93.3%) ilionyesha idadi kubwa kuliko zote ya wafanyakazi wa kilimo ambao walichukua tahadhari wa walivaa vitu kujikinga wakati wa kutumia vijasumu, na mara nyingi wamekuwa na mchanganyo mzuri, wa vitu vya kujikinga, ikifuatiwa na Wundanyi (46.9%) na Homabay (5.6%). Hakuna hata mmoja kati ya wafanyakazi wa kilimo huko Migori aliyechukua tahadhari wakati wa kutumia vijasumu. Kadhalika, asilimia 91.3 ya wafanyakazi wa kilimo huko Naivasha walikuwa na vifaa vya kuosha/kuoga (92.7%), waliosha/walioga baada ya kutumia vijasumu (96%) na walibadili nguo zao mara tu baada ya kazi. Wakati wafanyakazi wa mashambani walioajiriwa na wenzao walichukua nafasi ya kwanza. Kwa habari ya vitu kujikinga na usafi binafsi, wale walioajiriwa na wale walikodi mashamba walishika nafasi ya mwisho. Nidhahiri, kuna umuhimu wa kuanzisha taratibu za kufundisha ili kuimarisha maarifa, ufahamivu na mazoezi ya wafanyakazi wakilimo Kenya kwa habari ya matumizi salama ya vijasumu.

Pia, maarifa, ufahamivu na mazoezi ya mabwana shamba (AEW) kwenye maeneo ya utafiti, yamekadiriwa kuzingatia usalama wa ushikaji/utumiaji wa vijasumu. Orodha ya maswali yenye nafasi ya kuandika majibu na yenye kujisimamia yenyewe ilitolewa kwa kingereza na kugawanywa kwa mabwana shamba 120 katika maeneo ya utafiti. Kiasi cha

washiriki kilikuwa asilimia 72. Kundi la kujisoma lilikuwa na asilimi 89 ya wanaume na asilimia 10.9 ya wanawake na lilikuwa na mabwana shamba wa vyeo tofauti. Mabwana shamba msaidzi wa kilimo (69.6%), mofisa wa kilimo (13%) na wasaidizi mashambani (field assistants). Muda wa utumishi katika kilimo unatufautiana kuanzia kama miaka 2 mpaka miaka 34 pamoja na asilimia 75 ya watumiaji wakiwa wamefanyakazi kwa miaka paka 15.

Matokeo yalionesha kuwa asilimia 33 ya mabwana shamba hawakujua matumizi ya vijasumu yanayohusika na utiaji na sumu na ni nusu tu ya watumiaji walijua. Zaidi ya hayo asilimia 68 ya mabwana shamba walielewa kuwa madhara ya vijasumu yalikuwa tatizo dogo tu katika jamii au kuwa vijasumu havikuwa na madhara yoyote yale. Wote walioulizwa walikubali kuwa wamekuzw wakitumia vijasumu katika shughuli za kilimo na pia walikuzw wakishiriki kuwashahuri wakulima juu ya njia salama za matumizi ya vijasumu, mkazo ukiwa zaidi juu ya kufuata maelekezo kama yalivyoandikwa kwenye makopo, utamiaji wanyenzo za kujikinga nguo/vifaa na usafi wa mtu binafsi, pia utunzaji katika sehemu zilizokavu, kufunga vizuri mastoo na kuhakikisha hewa inapita vizuri, kutunze vijasumu mbali na mwanga wa jua na mbali na moto au milipuko. Wote walioulizwa walikuwa na ufahamu kuwa vijasumu huweza kuingia mwili wa binadamu wakati wa kufanya kazi, na asilimia 90 ya walioulizwa walitoa taarifa ya kufahamu msaada wa kwanza wa kiafya juu ya kumsaidia mtu aliyekula sumu. Pamoja na hayo ilionekana wazi kuwa hawakufahamu kwa ukakika ni msaada upi wa kwanza unaothibitisha kutumika wakati mtu anapoathirika na sumu. Matumizi mengine ya njia za kulinda mimeo kama njia husishi za kuthibiti magongwa ya mimeo (IPM) yaligusiwa na watu wachache sana walioulizwa (2.2%) lakini elimu ya afya haikuguswa kabisa.

Mwisho, maarifa, ufahamu na utendaji kazi wa mabwana afya (HCW) ulipimwa, hususani ni kuhusu kupima, kuthibithi na kuzuia athari za sumu. Orodha wa maswali yanayojitegemea katika kingereza ulisambazwa kwa mabwana afya 137 katika eneo la utafiti. Ushiriki wa walengwa ulikuwa kwa kadri ya asilimia 78.8. Walengwa walikuwa pamoja na wanawake asilimia 52.8 na wanaume asilimia 47.2, hawa walijumuhisha kada mbali mbali za wafanyakazi wa afya: madaktari 1.5%; manesi 4.5%; manesi wa afya ya jamii 1.5%; manesi walioandikishwa nchini Kenya 6%; manesi na wakunga ambao wameorodheshwa

kwenye masomo 77%; manesi wasaidizi 4.5% na wengine, zaidi mabwana afya jamii na wataalam wa kafuti 5%; wenye wastani wa miaka 32.4 (21-52). Madaktari, maofisa wasaidizi wa madaktari na asilimia 75 ya manesi walioandikishwa na kuthibitishwa walipatikana mahospitalini, kwa upande mwingine manesi kwa upande wa Afya ya jamii na asilimia 45 ya manesi/wakunga walipatikana katika vituo vya Afya. Matokeo yanaonyesha kuwa mabwana afya katika vijiji hutoka katika kada ya chini, ambapo asilimia 77 ya wafanyakazi wa afya waliohusishwa wanafanyakazi katika vituo vya afya na dispensari. Ufahamu wa wafanyakazi wa afya vijijini kuhusu madhara ya athari za sumu na vijasumu kuwa ni tatizo na uzito wa tatizo hiliulikuwa wa chini sana, kiasi cha asilimia 17 tu ndio walioonyesha kufahamu uwepo wa tatizo hili. Maarifa juu ya njia au mifumo ambayo huingiza sumu ndani ya mwili wa binadamu wakati wa kufanya kazi yalikuwa haba sana na hayakuwa na uhakika wowote: kiasi cha asilimia 68 ya walengwa walitaja kula kama njia ya kuingiza sumu mwilini na ni asilimi 4.8 tu waliotaja ngozi kama njia ya kuingiza sumu mwilini ambayo ndiyo njia kuu wakati wa kufanya kazi na sumu. Ni jambo muhimu pia kuzingatia kuwa asilimia 30 ya walengwa walioulizwa maswali hawakuwahi kuona mtu aliyeathirika na sumu katika kipindi cha kufanya kazi na kutoa huduma kama mabwana afya na hata sasa asilimia 5 wameona matekeo kati ya 10 hadi 70 ya athari za sumu zilizohughulikiwa nao. Hii inaonyesha kuwa athari za sumu na vifo kutokana na sumu linaweza kuwa ni tatizo la sehemu fulani huko mashambani na lisiwe tatizo katika sehemu nyingine mashambani kutegemea na njia zinazotumiwa kuhifadhi mimea na mazao na pia kutegemeausalama wa kujikinga unaotumiwa. Athari za sumu na vifo kutokana na sumu ni jambo gumu kuthibiti na kuepusha bila maarifa na vifaa muhimu na madawa. Ni asilimia 20 tu ya mabwana afya waliothibitisha kuwa na uwezo na nyenzo za lazima kutibu athari za sumu. Waliobaki walikuwa wanabahatisha na matokeo yake ni kuwa na njia zisiozokuwa za hakika katika kutibu na kuthibiti athari za sumu, kuhusu ushauri na mapendekezo ambayo mabwana afya huwapa wakulima, ilionekana kuwa asilimia 82 ya walengwa walioulizwa maswali walikuwa na uwezo wa kutoa habari juu ya maswala ya afya yanayoambatana na vijasumu. Hata hivyo, asilimia 30 ya habari zilielekezwa kwa jamii kwa ujumla, asilimia 23 ya habari ililengwa kwa wagonjwa waliopata huduma katika vituo vya afya, na ni asilimia 8 tu ya habari iliyolengwa kwa wakulima. Asilimia 50 ya mabwana afya walitoa habari kuhusu maswala ya utunzaji wa vijasumu na utumiaji, wakati huohuo asilimia 14 ya habari ilihusu msaada wa kwanza hususani ni wakati mtu

anapoathirika na sumu. Ni asilimia 3 tu ya walengwa walioulizwa walitoa ushauri juu ya maelekezo juu ya matumizi ya vijasumu, asilimia nyingine 3 ya walengwa walitoa habari juu ya ufahamu wa ujumla na taarifa za kiafya hususani ni juu ya vijasumu. Walengwa walioulizwa walionyesha kuwa kulikuwa na matukio mengi ya kuathirika na sumu ambayo hayakuwafikia au kushughulikiwa na wafanyakazi wa afya na kwamba mengi ya matukio haya yalihusu wafanyakazi wa mashamba (24.5%) na sababu za kutoripoti madhara ya sumu zilitofautiana kutoka kutojali (45% hadi kutumia sumu kwa lengo la kujiua (9%), ukosefu wa elimu juu ya athari za sumu (3%) na kutoweza kufuata masharti na maelekezo ya matumizi ya madawa ya sumu (1.5%). Karibu mabwana afya wote walionyesha nia yao ya kutaka kukwepa madawa na vipoza sumu kwa ajili ya kuthibiti na kutibu athari za sumu. Kwa kuongezea walionelea pia kuhitaji nyenzo za kutoa sumu tumboni, kwenye mishipa ya damu na mipira ya kunyonya sumu kupitia pua hadi tumboni. Pia walionyesha nia ya kutaka kupata habari na mafunzo juu ya maswala ya kiafya yatokanayo na mwili kufuatana na sumu hususani ni juu ya kupima, kuelezea na kuthibiti/kutibu athari za sumu na matokeo ya mwili kuwe kwa wazi kwa sumu na athari zake juu ya afya ya binadamu kwa ujumla. Aghalabu ni asilimia ndogo 33 ya wafanyakazi wa afya waliotoa ushauri kuwa njia ya uhakika wa kuzuia athari za sumu kutoka vijasumu katika jamii ni kupitia elimu ya afya. Asilimia 29 ya wafanyakazi wa afya walizungumzia kutunza kwa njia za usalama, hususani ni kuhusu athari za sumu zitokanazo na ajali/makusudi kama njia ya uhakika ya kuweka mkakati wa kuzuia madhara ya sumu.

Huu pekee ni uchunguzi wa ufahamu au kina ambao umewahi kufanyika kuhusu athari za sumu kati ya wafanyakazi wa mashambani nchini Kenya wanaojihusisha na matumizi ya sumu katika shughuli zao. Uchunguzi huu unatoa picha ya kuaminika kuhusu wingi wa wafanyazai wa mashambani kutoka mashamba madogo na yale makubwa kutoka mikoa mbali mbali nchini. Na kwa kuongeza, uchunguzi huu unatoa picha kamili ya aina ya vijasumu na mazao yanayotumia sumu hizi. Uchunguzi huu umeonyesha pia matokeo ya kifiziologia yatokanayo na mwili kuwekwa wazi kwa sumu, umeainisha sababu zinazohusika na alama zionyesha madhara ya sumu. Zaidi ya hayo, elimu uelewa, na utendaji kazi uliangaliwa kati ya makundi matatu ya walengwa: wafanyakazi wa mashambani, mabwana shamba na mabwana afya. Matokeo yanaonyesha kuwa ni lazima kuboresha hali hii ya kusikitisha na juhudi inahitajika haraka sana kama uchunguzi huu ulivyoonesha,

vyanzo vya kuathirika na sumu ni matokeo ya mazingira ya watu wanamoishi na tabia zao. Malengo ya jumla ya uchunguzi au utafiti huu, pia na malengo ya sehemu husika au walengwa husika wa sehemu yamefikwa.

Ni wazi kuwa mkazo zaidi uwekwe kwenye afya ya wafanyakazi katika sekta ya kilimo katika nchi zinazoendelea. Ushauri wa ujumla kuingilia kati kuhusu tatizo hili, hii inaainisha, sababu husika za kiafya zinazoshabiana na mwenendo na mazingira ambazo zinaweza kuonishwa na matatizo ya kiafya yenye kuhitaji kupewa kipa umbele. Matokeo ya uchunguzi huu yamegundua mianya ya kuziba ifuatayo hususani ni kuhusu sera za kazi na afya, usimamiaji na uratibu wa sera hizi. **Sasa hivi ni lazima na haraka kuanzisha mikakati ya kuingilia kati ili kuthibiti mianya ilijioneysa. Matokeo ya uchunguzi huu, yatasaidia kuanzishwa kwa mkakati wenye sura nyingi ili kuratibu, kuzuia na kuthibiti madhara ya mwili kuwa wazi kwa vijasumu katika nchi ya Kenya na nchi nyingine zinazoendelea.**



## Samenvatting

In de meeste ontwikkelingslanden worden geen statistieken van ongevallen met pesticiden bijgehouden, laat staan statistieken over het voorkomen van gezondheidseffecten ten gevolge van de blootstelling aan pesticiden. Informatie met betrekking tot de import en het gebruik van pesticiden in deze landen is eveneens zeer moeilijk te verzamelen. In dit proefschrift worden importgegevens gepresenteerd voor Kenia over de jaren 1989-1993. De 370 bij de Keniase Pest Control Products Board (PCPB) voor gebruik geregistreerde formuleringen bestonden uit 217 actieve stoffen. Gemiddeld 22% van het volume geïmporteerde pesticiden waren zeer toxisch (klasse 1) volgens de door de Wereldgezondheidszorg Organisatie (WHO) gehanteerde classificering, terwijl 20% als gematigd toxisch en 45% als minder toxisch worden beschouwd. De rest van de geïmporteerde pesticiden kon niet worden geclassificeerd. Een aanzienlijk deel van de als zeer toxisch geclassificeerde pesticiden werden echter geïmporteerd als zgn. "technical grade" stoffen hetgeen na lokale formulering resulteerde in een groter deel zeer toxische pesticiden t.o.v. de minder toxische pesticiden die kant en klaar werden geïmporteerd. Anorganische middelen maakten het grootste deel uit van de gebruikte pesticiden (21% van de geïmporteerde pesticiden). Zij werden gevolgd door organofosfaten (15%), organochloorverbindingen (11%), thiocarbamaten (7%) en phtalamiden (7%). Sommige in andere landen verboden of strikt gereguleerde pesticiden werden nog steeds in Kenia geïmporteerd of binnengesmokkeld vanuit naburige landen. Er is een duidelijke behoefte aan meer betrouwbare cijfers en er is een gezamenlijke inspanning nodig van alle factoren op het gebied van regelgeving en controle op het gebied van import en het gebruik van pesticiden.

De hoofddoelstelling van het in het proefschrift beschreven project was het vaststellen van de gezondheidsrisico's ten gevolge van het omgaan met de opslag en de toepassing van pesticiden in Kenia. Het betreft het gebruik in plantages en agrarische bedrijven, zowel grote als kleine in een aantal geselecteerde regio's in Kenia, waar katoen, tabak, en tuinbouwgewassen worden geteeld. Het idee was strategieën te ontwikkelen voor preventie en controle van pesticide vergiftigingen in Kenia en andere ontwikkelingslanden.

De specifieke doelstellingen waren: het vaststellen van de door het lichaam opgenomen

hoeveelheid en enkele geselecteerde pesticiden met behulp van biomonitoring technieken, het vaststellen van de frequentie van het voorkomen van gezondheidssymptomen gerelateerd aan deze blootstelling; het vastleggen van kennis, perceptie en werkmethoden van agrarische werknemers met betrekking tot omgang, opslag en gebruik van pesticiden; het beschrijven van patronen van opslag, mengen en spuiten van pesticiden, alsmede het gebruik van persoonlijke beschermingsmiddelen teneinde de omvang van mogelijke schadelijke praktijken te kunnen schatten; het vastleggen van kennis, perceptie en werkmethoden van landbouwvoorlichters met betrekking tot het veilig toepassen van pesticiden; het beschrijven van de kennis, perceptie en werkmethoden van gezondheids werkers met betrekking tot de diagnose, behandeling en preventie van pesticidevergiftigingen en tenslotte het ontwikkelen van aanbevelingen en richtlijnen voor het veilig toepassen van pesticiden voor zowel nationale overheden en controlerende overheidsorganen alsmede voor individuele boeren en agrarische werknemers.

De studie is uitgevoerd in een viertal studiegebieden. Studiegebied 1 omvatte uit werknemers (vnl. spuiters) van 10 boerderijen en plantages, variërend in omvang van 40 tot 1200 hectare in de Naivasha Divisie in het Nakuru District. De verbouwde gewassen waren bloemen, sperziebonen, aardbeien, druiven en andere tuinbouwgewassen voornamelijk bedoeld voor export naar Europa. De controle populatie voor dit gebied werd geselecteerd uit de werknemers van een grote sisal plantage in de Rongai Divisie in eveneens het Nakuru District. Dit gebied behoort tot dezelfde agro-ecologische zone als studiegebied 1 en de werknemers van deze sisal plantage waren vergelijkbaar voor wat betreft hun sociaal-economische status als de geselecteerde studiepopulatie. De studiepopulatie in gebied 2 betrof boeren van kleine tuinbouwbedrijven uit 14 sublokaties in de Wundanyi Divisie in het Taita-Taveta District en als controle populatie werden niet-blootgestelde kleine boeren in de directe nabijheid van de studiepopulatie gekozen. De studiepopulatie hield zich bezig met bijna jaarrond intensieve verbouw van groentegewassen voor de toeristenindustrie in Mombassa. In studiegebied 3 bestond de onderzoekspopulatie uit kleine boeren uit drie sublokaties in de West Karachuonyo Divisie in het Homabay District. Deze boeren verbouwden mais, bonen, gierst, sorghum en aardnoten gedurende de lange regentijd (februari-juli) en katoen als handelsgewas gedurende de korte regentijd (september-december). Bovendien werden een aantal tuinbouwers aan de

oevers van het Victoriameer geselecteerd, omdat zij pesticiden toepasten in de verbouw van tuinbouwgewassen, die werden verkocht aan inwoners van naburige steden. Controles voor dit gebied werden geselecteerd uit niet blootgestelde kleine boeren uit dezelfde sublokaties. In studiegebied 4 werden kleine boeren in de Centraal Migori lokatie van het Migori District geselecteerd, die mais, bonen, erwten en groenten verbouwden zonder toepassing van pesticiden, maar die wel intensief pesticiden gebruikten bij de verbouw van tabak (het voornaamste handelsgewas) op relatief kleine percelen (minder dan 0,2 hectare). De controles voor dit gebied werden geselecteerd uit kleine boeren uit Kabuoch 20 km verderop, die in het geheel niet werden blootgesteld aan pesticiden.

De landbouwvoorlichters en gezondheidswerkers werden gerecruteerd van instellingen binnen een straal van 15 km rond elk studiegebied.

Remming van acetylcholinesterase werd vastgesteld in het bloed van 666 Keniaanse boeren en agrarische werknemers gedurende 1993 en 1994. Van deze populatie was 58.6% pesticidespuiters en 41.4% niet-blootgestelde controle uit de vier gebieden. Remming van acetylcholinesterase kon worden vastgesteld in alle blootgestelde individuen met een gemiddelde vermindering van de cholinesterase uitgangsniveaus van gemiddeld 33%. In de controle populatie trad slechts een vermindering van 4% op. De blootgestelde werkers in Naivasha (voornamelijk bloementeelt) hadden de sterkste inhibitie (36%), gevolgd door de werkers in Homabay (voornamelijk katoenteelt) (35%) en in Wundanyi (groenteteelt) (33%). De tabakverbouwers in Migori vertoonden duidelijk minder inhibitie (26%). De acetylcholinesterase-niveaus van 115 blootgestelde werkers (29.6% van de populatie) waren afgenomen tot onder 60% van de uitgangsniveaus. Dit werk bij geen van de controles geconstateerd. Deze dramatische inhibitie van acetylcholinesterase activiteit kan leiden tot chronische en sub-klinische intoxicatie. Primaire preventie programma's voor het monitoren en controleren van beroepsmatige blootstelling aan betreffende pesticiden zijn op basis van deze bevindingen zeer noodzakelijk in Kenia en waarschijnlijk ook andere ontwikkelingslanden.

Met behulp van empirisch statistische modellen werden factoren geïdentificeerd en gekwantificeerd die verantwoordelijk waren voor de acetylcholinesterase activiteit. De

analyse werd uitgevoerd in de vier verschillende gebieden waar verschillende niveaus van inhibitie waren aangetoond, mogelijkveroorzaakt door verschillen in behandelde gewassen, verschillende applicatie-technieken, verschillen in persoonlijke hygiëne, beschikking over en gebruik van persoonlijke beschermingsmiddelen en verschillen in toegepaste pesticiden. De modellen bleken adequaat en verklaarden 57-70% van de geobserveerde variatie in acetylcholinesterase niveaus. De resultaten wezen op aanzienlijke verschillen in het voorkomen van mogelijke determinanten tussen de gebieden, vooral wat betreft persoonlijke beschermingsmiddelen, die niet aangetroffen werden in onderzoeksgebieden 3 en 4. Verschil in persoonlijke hygiëne tussen de vier gebieden was minimaal. WHO klasse I pesticiden werden vooral gebruikt in onderzoeksgebied 1. In dit gebied was de frequentie en volume van spuiten ook veruit het hoogst, terwijl in onderzoeksgebieden 2 en 3 het gebruik veel gematigder was. In onderzoeksgebied 3 werden bijvoorbeeld geen pesticiden uit de WHO klasse 1 gebruikt. Ondanks het hoge percentage werkers dat gebruik maakte van persoonlijke beschermingsmiddelen in onderzoeksgebied 1 ten opzichte van onderzoeksgebieden 3 en 4, was de inhibitie van achetylcholinesterase in gebied 1 het grootst. Het was niet duidelijk of dit een gevolg was van verhoogde dermale opname van pesticiden uit doorweekte persoonlijke beschermingsmiddelen of andere oorzaken. De situatie zou mogelijk nog slechter zijn geweest als geen gebruik was gemaakt van persoonlijke beschermingsmiddelen. In onderzoeksgebied 1 gebruikte het merendeel van de werkers laarzen, deze bleken slechts beschermend te zijn wanneer ze werden gecombineerd met een overall. Het alleen dragen van laarzen leidde tot meer inhibitie. Toegang tot een was- of badgelegenheid bleek een beschermend effect te hebben. Echter het wassen van de handen en het nemen van een bad leek meer reactief dan pro-actief handelen; de werkers bleken vooral over te gaan tot wassen van de handen en het nemen van een bad nadat er gemorst was of op een andere manier contaminatie had plaatsgevonden. Het spuiten bleek een groter effect op de cholinesterase activiteit te hebben dan het mengen van pesticiden. Ook kon worden aangetoond dat werkers die WHO klasse III pesticiden verspoten minder inhibitie (5%) hadden dan collega's, die meer toxische pesticiden toepasten. Helaas, bestond nauwelijks verschil in factoren als persoonlijke bescherming en hygiëne binnen de onderzoeksgebieden, waardoor de mogelijkheden van de statistische modellen om de effecten van dergelijke factoren te beschrijven sterk gelimiteerd waren.

De prevalentie van zelf gerapporteerde symptomen werd vervolgens gerelateerd aan de inhibitiëniveaus. Complete gegevens van slechts 256 blootgestelde werkers (41,1%) en 152 controles (29,5%) waren beschikbaar voor deze analyses. Elk van deze werkers werd gevraagd naar het voorkomen van symptomen (checklist met 42 symptomen) tijdens het tijdstip van het interview. Een factoranalyse bevestigde a posteriori het bestaan van verschillende clusters van symptomen, die a priori waren geïdentificeerd. De volgende clusters van symptomen werden in vervolganalyses gebruikt: huid/extremiteten, respiratoire, systemische, oog en centraal zenuwstelsel symptomen. Per cluster werd een positieve score van twee of meer symptomen gebruikt afhankelijk van het aantal symptomen in een cluster. De symptoom prevalentie was hoger gedurende de periode met hoge blootstelling dan in de periode met nauwelijks of geen blootstelling voor de blootgestelde onderzoekspopulatie, deze verschillen waren echter niet statistisch significant. Opvallend was de significante lagere prevalentie van symptomen voor de controles (Chi-kwadraat;  $p < 0,05$ ). De aanwezigheid van een relatie tussen acetylcholinesterase inhibitie en respiratoire, oog en centraal zenuwstelsel symptomen werd aangetoond. Verhoogde prevalentie van deze klachten werden geobserveerd bij acetylcholinesterase niveaus die tot voor kort als niet-schadelijk werden beschouwd. De aangetoonde verbanden zullen echter in een andere onafhankelijke studie met meer objectieve gezondheidsparameters moeten worden bevestigd.

De kennis, perceptie en geobserveerde en gerapporteerde werkmethoden met betrekking tot het veilig hanteren en toepassen van pesticiden werd eveneens onderzocht. Een gestructureerde vragenlijst werd afgenomen bij 390 werkers uit de vier onderzoeksgebieden in het Engels en ter plekke vertaald in Swahili of andere lokale talen. De onderzoeksgroep bestond voornamelijk uit mannen (92,8%) en voor een klein deel uit vrouwen (8,2%). Het merendeel van de onderzochte werkers was spuiters in Naivasha dan wel boer in Wundanyi, Homabay en Migori. Van de onderzoeksgroep had 68,5% elementair onderwijs gevolgd, 27,7% voortgezet onderwijs en slechts 3,3% had geen onderwijs gevolgd. Het merendeel van de respondenten had meerdere functies waaronder spuiten (88,1%), mengen (57,1%), schoonmaken en reparatie van spuitapparatuur (resp. 6,0 en 22,9%). Geen van de respondenten betrof pesticiden van de overheid, 63,1% betrof ze van coöperaties, 23,5% van detailhandelaren, 28,3% van tabaksbedrijven, 4,9% van

chemische bedrijven en 3,9% werd verkregen via smokkel uit naburige landen of gekocht op lokale markten. Een groot deel van de respondenten gaf aan dat de verstreckers van pesticiden voor instructies m.b.t. het veilig gebruiken van pesticiden zorgden: Naivasha (88,7%), Wundanyi (48,1%), Homabay (77,8%) en Migori (73,3%). Inhalatie (85,4%) en dermale blootstelling (75,3%) werden gekozen uit drie alternatieven als de belangrijkste toevoerwegen voor pesticiden in het menselijk lichaam. Ingestie werd als veel minder belangrijk gezien. Echter, 60% van de respondenten wist niet dat dermale blootstelling de meest belangrijke route voor pesticide vergiftigingen is. Beslissingen over het type pesticide en dosering werden in 81,3% van de gevallen genomen door leidinggevenden en bedrijfseigenaren in Naivasha, voor 59,8% door het tabaksbedrijf in Migori, terwijl in Wundanyi en Homabay voor respectievelijk 97,5 en 94,4% van de gevallen deze beslissingen werden genomen door de boeren zelf. Van de respondenten gaf 72,6% aan dat ze opslag hadden van pesticiden. De rest (37,4%) had geen opslag van pesticiden. In Naivasha had 96% van de respondenten hiervoor een speciale opslagplaats, voor Wundanyi, Momabay en Migori was dit respectievelijk: 43,2%, 28,9% en 45,6%. Andere vormen van opslag waren o.a. onder het bed, in het veld en in de latrine. Ongeveer 80% van de opgeslagen pesticiden waren in hun originele verpakking, voorzien van een etiket met instructies en goed afgesloten. De kans op het ontstaan van vuur en optreden van explosies in opgeslagen pesticiden was gering. Het merendeel van de bedrijven had geen recente inventaris van opgeslagen pesticiden dan wel registraties uit het verleden. Ongeveer de helft van de pesticide opslag plaatsen was droog, goed geventileerd en beschermd tegen zonlicht en hitte, terwijl slechts een derde goed afgesloten was en voorzien van een waarschuwingsteken. Het mengen bij de kleine boeren werd soms uitgevoerd in het woonhuis en bij de grote bedrijven op het bedrijf. Op 26% van de onderzochte bedrijven was kans op besmetting van (drink)waterbronnen, vooral tijdens het mengen en spuiten. Op 56,2% van de bedrijven werd het mengen uitgevoerd in de rugspuit zelf, op 33,6% van de bedrijven in een emmer en vervolgens overgegoten in de container. Op de rest van de bedrijven (voornamelijk grote bedrijven) werd in de "veldspuit" zelf of in de tanks gemengd. De meest gebruikte spuitapparatuur was de rugspuit (92,5%). Bijna 90% van de respondenten controleerde en assembleerde de spuitapparatuur zelf voor aanvang van het spuiten en 73,3% gaf aan dat ze de spuitapparatuur na gebruik schoonmaakte met zeep en water. De rest, voornamelijk kleine boeren,

gaven de apparatuur door aan de volgende boer of sloegen de apparatuur op zonder schoonmaken. In Naivasha rapporteerden bijna alle agrarische werkers (93,3%) dat ze voorzorgsmaatregelen troffen en persoonlijke beschermingsmiddelen gebruikten bij het werken met pesticiden. In Wundanyi en Homabay betrof dit slechts respectievelijk 46,9 en 5,6%, terwijl geen van de werkers in Migori voorzorgsmaatregelen trof of persoonlijke beschermingsmiddelen droeg. In Naivasha had 91,3% de beschikbaarheid over een was- of badgelegenheid, waste of baadde 92,7% zich direct na het gebruik van pesticiden en verwisselde 96% van kleren na het spuitwerk. Agrarische werkers in dienst van anderen scoorden het hoogst wat betreft het gebruik van persoonlijke beschermingsmiddelen en hygiëne, terwijl werkers ingehuurd door pachtboeren veruit het slechts scoorden op deze items.

Uit het bovenstaande blijkt duidelijk dat er een dringende behoefte is om trainingsprogramma's te implementeren gericht op het verbeteren van de kennis, perceptie en werkmethoden van agrarische werkers in Kenia met betrekking tot het veilig omgaan en toepassen van pesticiden.

De kennis, perceptie en werkmethoden met betrekking tot het veilig gebruiken van pesticiden van 120 landbouwvoorlichters uit de studiegebieden werd eveneens onderzocht met behulp van een gestructureerde vragenlijst. De respons bedroeg 72%. Deze groep bestond voornamelijk uit mannen (89,1%) en voor een klein deel vrouwen (10,9%) van verschillende niveau's assistenten (69,6%), voorlichters (13%) en veldassistenten (17,4%). De duur van hun aanstelling binnen de voorlichting varieerde van 2 tot 34 jaar, terwijl 75% van de respondenten minder dan 15 jaar binnen de voorlichting gewerkt had.

Van de voorlichters wist 33% niet welke handelingen met pesticiden tot vergiftigingen leidden en slechts de helft van de respondenten was bekend met de specifieke risico's van de in hun gebied gebruikte pesticiden. Bovendien vond 68% van de voorlichters pesticide vergiftiging slechts een klein probleem of helemaal geen probleem. Alle respondenten gaven aan dat ze in het kader van hun werk met pesticiden te maken hadden gehad. Bovendien waren ze betrokken geweest bij het adviseren van boeren op het gebied van veilig omgaan met pesticiden, met nadruk op het volgen van de instructies op de etiketten, het gebruik van persoonlijke beschermingsmiddelen en een goede persoonlijke hygiëne,

alsmede het zorgen voor opslag van pesticiden in een droge, afsluitbare ruimte met adequate ventilatie, niet in direct zonlicht en verwijderd van mogelijke vuur en explosiehaarden. Alle respondenten waren bekend met het feit dat pesticiden het menselijk lichaam kunnen binnendringen als gevolg van beroepsmatige blootstelling en 90% rapporteerden dat zij op de hoogte waren van eerste hulp procedures in het geval van vergiftigingen. Echter, uit de beschrijvingen van de meerderheid werd duidelijk dat ze niet op de hoogte waren van specifieke eerste hulp procedures, die aanbevolen worden voor bepaalde pesticide vergiftigingen. Het toepassen van andere methoden van gewasbescherming zoals geïntegreerde gewasbescherming werd slechts door een verwaarloosbaar deel van de geïnterviewden genoemd, terwijl gezondheidseducatie in het geheel niet werd genoemd als mogelijke maatregel.

Tenslotte, werd de kennis, perceptie en werkmethoden van gezondheidswerkers geïnventariseerd voor wat betreft de diagnose, behandeling en preventie van pesticide vergiftigingen. Een gestructureerde vragenlijst werd voorgelegd aan 137 gezondheidswerkers uit de vier onderzoeksgebieden. De respons was 78,8%. Deze groep bestond voor 52,8% uit vrouwen en voor 47,2% uit mannen. De mensen hadden een diverse professionele achtergrond: artsen (1,5%), klinici (4,5%), algemene verpleegkundigen (1,5%), geregistreerde verpleegkundigen (6%), niet-geregistreerde verpleegkundigen en verloskundigen (77%), hulp-verpleegkundigen (4,5%) en anderen (5%). De gemiddelde leeftijd bedroeg 32,4 jaar (range 21-52 jaar). Alle artsen, klinici en 75% van de geregistreerde verpleegkundigen waren afkomstig uit ziekenhuizen, terwijl de algemene verpleegkundigen en 45% van de niet-geregistreerde verpleegkundigen en verloskundigen afkomstig waren uit gezondheidscentra. De gezondheidswerkers in rurale gebieden waren gewoonlijk afkomstig uit het lagere kader. De perceptie van de gezondheidswerkers voor wat betreft de ernst van de vergiftigingen problematiek was matig, slechts 17% zag pesticiden vergiftigingen als een belangrijk gezondheidsprobleem. De kennis over de belangrijkste toewegingen van pesticiden in het menselijk lichaam tijdens beroepsmatige blootstelling was zeer matig en gebrekkig, maar liefst 68% noemde ingestie en slechts 4,8% noemde de dermale route als de belangrijkste toeweging. Opvallend was het feit dat slechts 30% van de respondenten ooit een geval van pesticide vergiftiging had gezien gedurende hun loopbaan in de gezondheidszorg, terwijl 5% van de respondenten 10-70 gevallen onder

hun aandacht hadden gekregen. Dit wijst in de richting van zeer lokale problemen, die kunnen optreden in sommige rurale gebieden afhankelijk van de wijze van gewasbescherming en kennis over het veilig toepassen van pesticiden.

Vergiftigingen zijn moeilijk te behandelen en te controleren zonder aanwezige kennis en noodzakelijke medicijnen en medische apparatuur. Slechts 20% van de gezondheidswerkers rapporteerden dat zij in staat waren en de nodige middelen tot hun beschikking hadden om vergiftigingsgevallen te behandelen. De rest van de ondervraagden moest improviseren met als resultaat gebrekkige behandelingswijzen. Voor wat betreft de adviezen die gezondheidswerkers aan boeren en andere agrarische werkers gaven, bleek 82% van de respondenten informatie te kunnen geven over de gezondheidsaspecten bij het toepassen van pesticiden. Echter 30% van de informatie was gericht op de gemeenschap in het algemeen, 23% op patiënten die naar de gezondheidszorgcentra kwamen en slechts 8% op boeren en andere agrarische werkers. 50% van de gezondheidswerkers verstrekte informatie met betrekking tot de opslag en gebruik van pesticiden en 14% verstrekte informatie over eerste hulp bij pesticide vergiftigingen. Slechts 3% van de respondenten gaf advies over het volgen van gebruiksaanwijzingen, algemene kennis van het probleem en gezondheidsinformatie.

De respondenten gaven aan dat veel gevallen van pesticide vergiftigingen niet onder de aandacht komen van gezondheidswerkers en dat dit vooral het geval was onder agrarische werkers (24,5%). Als mogelijke redenen werden aangegeven: onachtzaamheid (45%), zelfdoding (9%), gebrek aan kennis (3%) en het niet kunnen volgen van instructies (1,5%). Bijna alle gezondheidswerkers gaven aan zeer positief te staan tegenover het verstrekken van medicijnen en tegengiften voor de behandeling van vergiftigingen. Bovendien, gaven de respondenten aan dat zij medische apparatuur om maag en neusspoelingen uit te voeren ontbeerden. Ook gaven zij aan, informatie en training nodig te hebben op het gebied van gezondheidsaspecten van blootstelling aan pesticiden, vooral wat betreft de diagnose, en behandeling bij vergiftigingen en meer algemeen, de effecten van blootstelling aan pesticiden op de gezondheid. Een relatief laag percentage van de gezondheidswerkers (33%) zag gezondheidseducatie als de meest effectieve manier om pesticide vergiftigingen te voorkomen. Veilige opslag, vooral in relatie tot niet-bewuste en

bewuste vergiftiging werd door 29% genoemd als de meest effectieve wijze van preventie.

De studie beschreven in dit proefschrift is de enige complete studie tot nu toe op het gebied van beroepsmatige blootstelling aan pesticiden onder Keniase agrarische werkers. De studie geeft een betrouwbaar beeld voor de populatie agrarische werkers van zowel kleine als grote bedrijven in verschillende regio's van het land. Bovendien geeft het een compleet beeld van de typen toegepaste pesticiden en de gewassen waarin ze worden toegepast. Deze studie heeft aandacht besteed aan de fysiologische effecten van de daadwerkelijke blootstelling. Tevens zijn de factoren verantwoordelijk voor de blootstelling geïdentificeerd en resulterende gezondheidssymptomen in kaart gebracht. Bovendien werd bij drie groepen factoren te weten: agrarische werkers, voorlichters en gezondheidswerkers de kennis, perceptie en gehanteerde werkmethoden met betrekking tot de pesticiden problematiek geïnventariseerd. De resultaten laten zien dat actie geboden is om de huidige situatie te verbeteren en dat oorzaken zowel als mogelijkheden voor preventie van vergiftigingen zowel omgevingsfactoren als in het individuele gedrag te vinden zijn. De algemene doelstelling alsmede de specifieke doelstellingen van de studie zijn grotendeels gehaald.

Het zal duidelijk zijn dat met betrekking tot het gebruik van pesticiden meer aandacht nodig is op het gebied van arbeid en gezondheid van agrarische werkers in ontwikkelingslanden. Algemene aanbevelingen voor interventies omvatten het identificeren van specifieke aan gezondheid gerelateerde omgevings- en gedragsfactoren die vervolgens gekoppeld kunnen worden aan de gesignaleerde gezondheidsproblemen. De beschreven studie heeft de omgevings- en gedragsfactoren geïdentificeerd. Daarnaast zijn politieke, regelgevende en organisatorische implicaties voor Kenia in aanbevelingen weergegeven. **Het is nu noodzakelijk om op zeer korte termijn interventies te initiëren om de gesignaleerde tekortkomingen aan te pakken. De resultaten van deze studie maken het mogelijk maken effectieve veelomvattende strategieën te ontwikkelen voor de preventie en beheersing van (schadelijke effecten) van beroepsmatige blootstelling aan pesticiden in Kenia en andere ontwikkelingslanden.**



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In 1992, when I completed my MSc degree course in Environmental Science and Technology, I discussed with Prof. Jan Koeman, the possibility of pursuing a Sandwich PhD degree in toxicology at Wageningen Agricultural University. I was offered a sandwich scholarship in 1993 and consequently wrote a proposal for field research on the effects of industrial pollution on the ecosystems of the mangrove swamps on the Kenyan Coast. My supervisor Dr Hans Temmink and I, immediately embarked on identifying possible collaborators and funding agencies for this part of the study which was to last three years. After mapping out our sampling points along the Kenyan Coast and identifying laboratories for analysis of samples, we looked for funding for three years of research. However, we were unable to secure funding for this expensive toxicological project despite intensive applications to national, bilateral and multilateral agencies. In the meantime, funding had been secured for a large regional epidemiological study, the East Africa Pesticides project and so we saw the possibility of utilizing an already funded project for a PhD dissertation. As a result, Hans arranged for having my registration transferred from the Department of Toxicology to the Department of Epidemiology and Public Health. In August 1997, I was registered for a Sandwich PhD in Environmental and Occupational Health. I would like to sincerely thank Dr Hans Temmink for helping me to realize my dream, and for his continued interest in my work and his kindness and generosity. I would also like to thank his wife Margaret for welcoming me into their house and the dinners that she prepared for me countless times. I will always cherish their friendship and commitment.

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## Curriculum Vitae

Jane Grace Adikinyi Ohayo-Mitoko was born on August 31st, 1959 at Soroti in Uganda. From 1977 to 1980, she studied at the University of Nairobi where she obtained a BSc degree (First Class Honours) in Chemistry, Mathematics and Education. After graduation she was employed by the International Laboratory for Research on Animal Diseases (ILRAD; now ILRI, the International Livestock Research Institute) as a research associate in the Immunochemistry department. In November, 1981, she joined the University of Nairobi to pursue an MSc degree in Environmental Chemistry. Between 1984 and 1987, she worked for the Ministry of Transport and Communications, Materials Branch as an analytical chemist. In 1988, she joined the Kenya Medical Research Institute, Medical Research Centre as a research scientist in the Division of Environmental, Occupational Health and Cancer Research. In October, 1990, she joined the Institute of Infrastructural, Hydraulic and Environmental Engineering (IHE), in Delft The Netherlands where she graduated with a Post-Graduate Diploma in Environmental Science and Technology in September, 1991 and an MSc degree in Science and Technology (Ecotoxicology) in March, 1992. She joined the Department of Epidemiology and Public Health at Wageningen Agricultural University in August 1996 to undertake a Sandwich PhD degree course based on the Kenyan component of a regional four-year research project "The East African Pesticides Network Project".

She has, also, attended several training courses, workshops and symposia, among them the International Atomic Energy Agency (IAEA) Course in Radiochemistry and Analytical Techniques (Nairobi, 1985); the IAEA on Nuclear Analytical Techniques Applied to Environmental Pollution Studies (Karlsruhe/Seibersdorf, 1993).

Apart from her permanent job at the Kenya Medical Research Institute, Mrs. Ohayo-Mitoko is also a part-time lecturer in Environmental Health at the Department of Community Health, Medical School, University of Nairobi. In addition, she has undertaken several short-term consultancies for donor agencies and is involved in voluntary work for Non-Governmental Organizations such as Pesticide Action Network. She is a member of several professional organizations, among them the United Nations Environment Programme (UNEP) Methyl Bromide Technical Options Committee (MBTOC).

Grace is married to Micah H. Mitoko, a financial consultant for the World Bank in Nairobi and they are blessed with three children; Micah Jr. (Papa), Christine Angela (Dani) and Truphosa (Mama).

