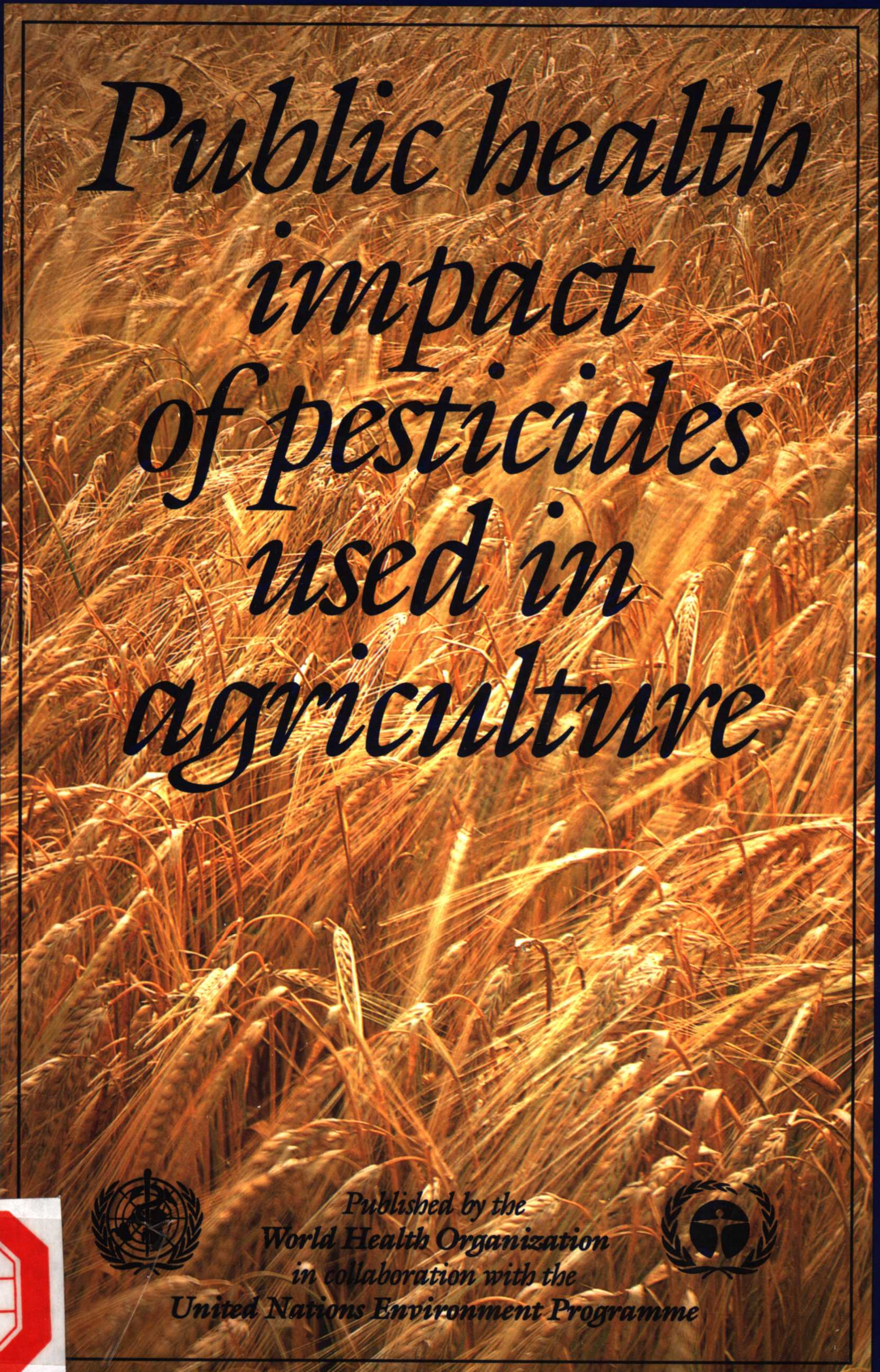


Public health impact of pesticides used in agriculture

Published by the
World Health Organization
in collaboration with the
United Nations Environment Programme

PUBLIC HEALTH IMPACT OF PESTICIDES USED IN AGRICULTURE

WORLD HEALTH ORGANIZATION
GENEVA
1990

WHO Library Cataloguing in Publication Data

Public health impact of pesticides used in agriculture.
1. Pesticides – adverse effects   2. Pesticides – poisoning
ISBN 92 4 156139 4   (NLM Classification: WA 240)

The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of the Secretariat of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

The mention of specific companies or of certain manufacturers' products does not imply that they are endorsed or recommended by the World Health Organization in preference to others of a similar nature that are not mentioned. Errors and omissions excepted, the names of proprietary products are distinguished by initial capital letters.

TYPESET IN INDIA
PRINTED IN ENGLAND
90/8430 — Macmillan/Clays — 4500

CONTENTS

PREFACE

Concern about the effects of pesticides on health has been voiced in a number of reports, and activities to prevent such effects are carried out in most countries and at an international level. As pesticides are inherently toxic to living organisms, they are more likely to affect the health of human beings than other agricultural chemicals. However, the toxicity for human beings of different pesticides varies greatly and adverse affects on health may be prevented by choosing the least toxic pesticide, as well as by measures to reduce human exposure. The users of pesticides in agriculture have an obligation to prevent any adverse side-effects on health.

Even though a number of studies have been carried out on the problems of acute occupational, accidental, and suicidal poisonings by pesticides, there is a general lack of epidemiological data on the impact of pesticides on human health. Some follow-up studies of workers occupationally exposed to these chemicals have looked for chronic effects, but, because of methodological difficulties, the number of epidemiological studies of such effects has been small. Similarly, while exposure data are available for some populations (e.g., the occurrence of certain pesticides in human milk), there are few evaluations of the long-term effects.

The objective of the present publication is to assess the scope and severity, globally and regionally, of exposure to pesticides, to estimate future trends, and to review the effects of pesticides on human health, with particular reference to the general population in developing countries. The assessment is based primarily on published reports of the health effects of individual pesticides and on data collected by WHO and by UNEP (through the International Register of Potentially Toxic Chemicals). Most of the published reviews refer to the lack of information and the need for further epidemiological research on human exposures and health effects, and these shortcomings will naturally limit the scope of the present review.

This report is intended for use principally by the national health officials responsible for pesticide management and by research workers interested in the epidemiology of pesticide poisoning. Legislators, officers responsible for enforcing national regulations, and personnel involved in designing, developing, and implementing training programmes concerned with the health of agricultural workers and environmental protection will also find useful information in the report.

*

* *

A preliminary draft of the report was prepared by: Dr U. Ahlborg, Toxicology Unit, National Institute of Environmental Medicine, Stockholm, Sweden; Dr M. Akerblom, National Laboratory for Agricultural Chemistry, Uppsala, Sweden; Dr G. Ekström, National Food Administration, Uppsala, Sweden; Dr C. Hogstedt, National Institute of Occupational Health, Solna, Sweden; Dr T. Kjellström, Division of Environmental Health, World Health Organization, Geneva, Switzerland; and Dr O. Pettersson, University of Agricultural Sciences, Uppsala, Sweden. This draft was then revised by a WHO/UNEP Working Group, which met in Tbilisi, USSR, on 23–27 November 1987. The members of the Working Group are listed below.

Funds for the preparation of the report and for the Working Group meeting were provided by the Swedish National Board of Occupational Safety and Health, UNEP, and WHO. The Institute of Sanitation and Hygiene of the Georgian Soviet Socialist Republic kindly hosted the meeting and all practical arrangements were made by the USSR Centre for International Projects. Valuable contributions to the text of the report were received from many staff in FAO, UNEP, and WHO, and from the International Group of National Associations of Manufacturers of Agrochemical Products.

WHO/UNEP Working Group on Public Health Impact of Pesticides Used in Agriculture

Dr U. Ahlborg, Toxicology Unit, National Institute of Environmental Medicine, Stockholm, Sweden

Dr M. Akerblom, National Laboratory for Agricultural Chemistry, Uppsala, Sweden

Dr W. Almeida, National Institute of Health Control, INCQS/FIOCRUZ, Rio de Janeiro, Brazil

Dr G. Ekström, National Food Administration, Uppsala, Sweden

Dr C. Hogstedt, National Institute of Occupational Health, Solna, Sweden (*Chairman*)

Dr M. Jaghabir, Department of Community Health, Jordan University, Amman, Jordan

Dr J. Jeyaratnam, Department of Community, Occupational and Family Medicine, National University of Singapore, Singapore

Dr F. Kaloyanova, Institute of Hygiene and Occupational Health, Sofia, Bulgaria

Dr T. Kjellström, Division of Environmental Health, World Health Organization, Geneva, Switzerland (*Secretary*)

Dr R. Levine, Nassau County Department of Health, New York State Department of Public Health, Mineola, NY, USA

Dr N. Maizlish, Occupational Health Surveillance and Evaluation Program, Berkeley, CA, USA

Dr G. Molina, Pan American Center for Human Ecology and Health, World Health Organization, Metepec, Mexico

Dr D. Mowbray, South Pacific Regional Environment Programme, Biology Department, University of Papua New Guinea, Waigani, Papua New Guinea

Dr J. N'Kurlu, Factories Inspectorate, Ministry of Labour and Manpower Development, Dar-es-Salaam, United Republic of Tanzania

Dr O. Pettersson, University of Agricultural Sciences, Uppsala, Sweden

Dr V. Polchenko, Laboratory of Systems Analysis of Public Health, Institute of Hygiene and Toxicology of Pesticides, Polymers, and Plastics, Kiev, USSR (*Vice-Chairman*)

Dr Y. Kagan, Chief, Department of Experimental Toxicology, Institute of Hygiene and Toxicology of Pesticides, Polymers, and Plastics, Kiev, USSR

Dr F. Xu, Institute of Environmental Health Monitoring, Beijing, China

Chapter 1

INTRODUCTION

What is a pesticide?

Most pesticides are chemicals that are used in agriculture for the control of pests, weeds, or plant diseases. These chemicals may be extracted from plants or may be "synthetic". This report will deal with those synthetic pesticides that represent potential hazards to public health.

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,[1] 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 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.

Some pesticides are used both in agriculture and as vector control agents in public health programmes. Agriculture and horticulture, together with vector control programmes, account for the greatest use of pesticides. Significant amounts are also used in forestry and livestock production.

Some pesticides are of biological origin. One example is *Bacillus thuringiensis*, which is used in public health programmes to control mosquitos that transmit malaria and

[1] The term "agricultural commodities" refers to commodities such as raw cereals, sugar beet, and cottonseed, that might not normally be considered as food.

Simulium sp., the vector of onchocerciasis (river blindness), as well as in agriculture against lepidopteran pests.

Most pesticide preparations include carrier substances in addition to the active ingredients and also solvents and compounds that improve absorption, etc. These "inert ingredients" are not usually included in any discussion of the effects on health although they frequently comprise a large part of a commercial pesticide product, and their adverse effects may exceed those of the active ingredients. For example, carbon tetrachloride and chloroform, both potent agents that are toxic to the liver and central nervous system, may be used as "inert" ingredients without being mentioned on the product label. The adverse effects of pesticides on health may also be caused by impurities, such as dioxins in certain phenoxyacid herbicides, ethylene thiourea in ethylene bisdithiocarbamate fungicides, and isomalathion in malathion.

Types of exposure

Different groups and segments of a population are exposed to pesticides in different ways and in different degrees. Some exposures are intentional (suicides and homicides) and some are unintentional (Fig. 1).

Davies et al. (1980) and Davies (1984) described categories of pesticide exposure and the approximate size of the populations at risk in each case (Fig. 2). They used a triangle to represent the large population with low-level exposure, and a smaller group with extreme exposures. As will be discussed in Chapter 7, these relative population sizes do not necessarily reflect the number of poisonings that occur.

Fig. 1. Types of exposure to pesticides

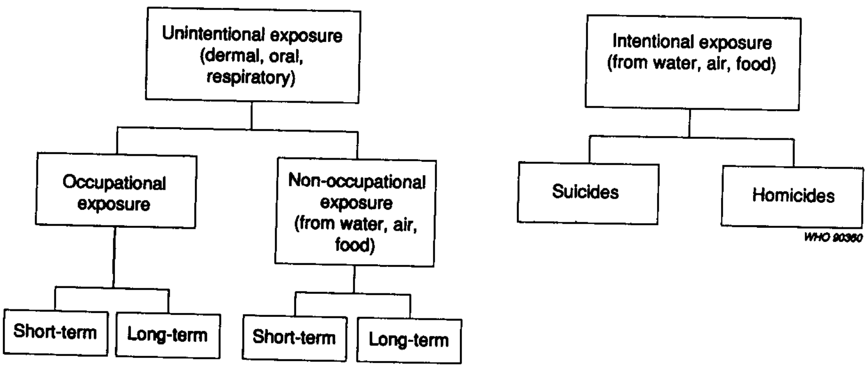
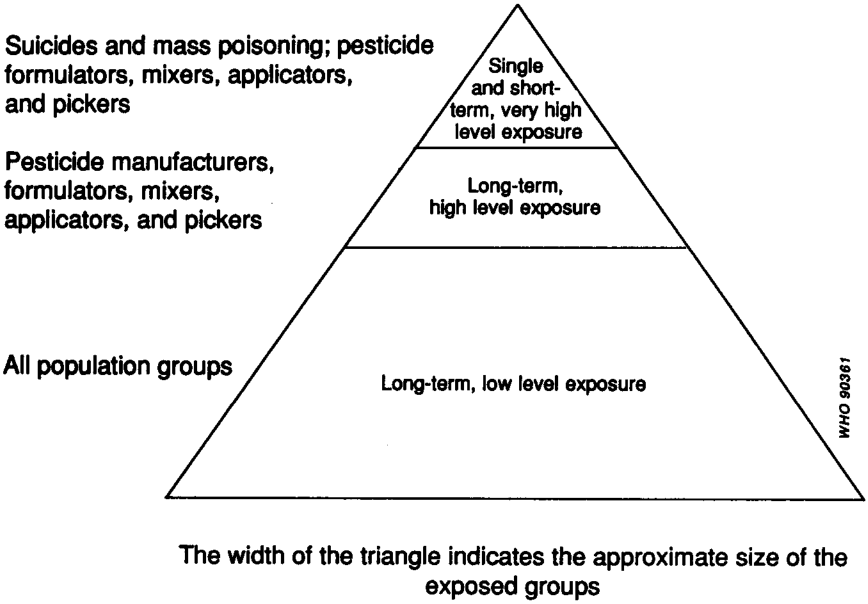


Fig. 2. Population groups at risk of exposure to pesticides[a]



[a] Adapted from Davies et al. (1980) and Davies (1984).

Assessing the public health impact

Assessment of the public health impact of agricultural pesticides must include an estimation of the number of cases of severe and minor health effects, the number of fatalities and hospitalizations, and the effect on the health services of the treatments required. In some cases, sufficient data might be available to estimate the financial implications of the effects on the health services and the loss to society caused by the health effects. Any beneficial effects on health should be quantified in a similar way if possible.

A study of the indirect costs resulting from pesticide use in the United States of America (Pimentel et al., 1980) showed that they included: 45 000 nonfatal and fatal human cases of poisoning per year (the economic cost not estimated); US$ 12 million as a result of livestock losses; US$ 287 million as a result of a reduction in natural enemies and because of pesticide resistance; US$ 135 million resulting from honey-bee poisoning and reduced pollination; US$ 70 million as a result of losses of crops and trees; US$ 11 million as a result of fish and wildlife losses; and US$ 140 million from miscellaneous losses. However, the 45 000 cases of poisoning and the US$ 839 million annual losses attributed to pesticide use may represent only a portion of the actual costs. Pimentel et al. (1980) pointed out that a more complete summation of the indirect costs would provide higher estimates. The purchase price of the pesticides used was estimated at US$ 2800 million and the estimated production benefits were US$ 10 900 million.

Thus the assessment of the public health impact is similar to environmental health impact assessment and to risk assessment. The items to be included are outlined in Table 1. In the following sections of this book, the available data on exposure to, and the health effects of, pesticides are analysed with these items in mind. Several of the items cannot be quantified because of lack of data.

Table 1. Factors to consider when estimating the impact of pesticide usage in agriculture on public health in developing countries

The total population at risk is divided into subpopulations with different average pesticide exposure levels:

- rural populations with traditional life-style and virtually no pesticide exposure;
- rural populations in areas with low use of pesticides;
- rural populations in areas with high use of pesticides, who are exposed through food, air, and water supply;
- rural populations in areas with high use of pesticides, additionally exposed via direct contact (for instance occupation);
- urban populations in areas with low use of pesticides on crops;
- urban populations in areas with high use of pesticides on crops;
- urban populations with additional direct contact exposure.

For each specific pesticide, the public health significance should be estimated, taking into account:

- effects on mortality in general;
- influence of mortality rates on productivity (need to take age-specific mortality into account);
- effects on overt disease morbidity (disease that disables the victim at least temporarily);
- influence of overt disease morbidity on occurrence of permanent disability;
- influence of overt disease morbidity on productivity (absence from work and daily duties);
- influence of overt disease morbidity on medical care services (staff use, drug use, bed use, costs);
- effects on the occurrence of lesser symptoms, and of physiological or biochemical changes;
- influence of these changes on sensitivity to other environmental factors, nutritional deficiencies, etc.

Chapter 2

PRODUCTION AND USE OF PESTICIDES

A short history

This short summary of the history of pesticide use is based on a review by Hassall (1982). The use of inorganic chemicals to control insects possibly dates back to classical Greece and Rome. Homer mentioned the fumigant value of burning sulfur, and Pliny the Elder advocated the insecticidal use of arsenic and referred to the use of soda and olive oil for the seed treatment of legumes. The Chinese were employing moderate amounts of arsenicals as insecticides by the sixteenth century and not long afterwards nicotine was used, in the form of tobacco extracts. By the nineteenth century, both pyrethrum and soap had been used for insect control, and also a combined wash of tobacco, sulfur, and lime to combat insects and fungi.

The middle of the nineteenth century marked the beginning of the first systematic scientific studies into the use of chemicals for crop protection. Work on arsenic compounds led to the introduction in 1867 of Paris green, an impure form of copper arsenite. It was used in the USA to check the spread of the Colorado beetle and by 1900 its use was so widespread that it led to the introduction of what was probably the first pesticide legislation in the world.

In 1896 a French grape grower, applying Bordeaux mixture (copper sulfate and calcium hydroxide) to his vines, observed that the leaves of yellow charlock growing nearby turned black. This chance observation demonstrated the possibility of chemical weed control, and shortly afterwards it was found that iron sulfate, when sprayed on to a mixture of cereal and weeds, killed the weeds without damaging the crop. Within a decade several other inorganic substances had been shown to act selectively at appropriate concentrations. Another important landmark was the introduction of the first organomercury seed dressings in 1913 in Germany.

In the years between the First and Second World Wars, both the number and the complexity of chemicals for crop protection increased. Tar oil was, and still is, used to control the eggs of aphids on dormant trees. Dinitro-orthocresol was patented in France in 1932 for the control of weeds in cereals, and in 1934 thiram, the first of several dithiocarbamate fungicides, was patented in the USA.

During the Second World War, the insecticidal potential of DDT was discovered in Switzerland and insecticidal organophosphorus compounds were developed in Germany. At about the same time, work was in progress in the United Kingdom that was to lead to the commercial production of herbicides of the phenoxyalkanoic acid group. In 1945, the first soil-acting carbamate herbicides were discovered by workers in the United Kingdom and the organochlorine insecticide chlordane was introduced in the USA and in Germany. Shortly afterwards, the insecticidal carbamates were developed in Switzerland.

In the period from 1950 to 1955, urea derivatives were developed as herbicides in the USA, the fungicides captan and glyodin appeared, and malathion was introduced. Between 1955 and 1960, other new products included herbicidal triazines and quaternary ammonium herbicides. Dichlobenil, trifluralin, and bromoxynil were described between 1960 and 1965 and the systemic fungicide benomyl in 1968. The leaf-acting herbicide glyphosate was introduced soon afterwards.

During the 1970s and 1980s many new pesticides were introduced. They have been based on a more thorough understanding of biological/biochemical mechanisms, and they are often more effective at lower doses than the older pesticides. The best examples of this new generation of pesticides are the herbicidal sulfonylureas and the new systemic fungicides, such as metalaxyl and triadimefon. A new and important group of insecticides comprises synthetic light-stable pyrethroids, which have been developed from the naturally occurring pyrethrins.

As a result of a better knowledge of host–pest interactions, a new approach to the design of pesticides is now being developed, as well as new strategies for formulations, and new methods of application. These developments provide an opportunity to reduce the risk of pesticide poisoning. The potential usefulness of microbial and other biological pest control agents is at present being studied by several research institutions around the world.