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# THE PESTICIDE DILEMMA IN DEVELOPING COUNTRIES

D. J. Ecobichon

*Department of Pharmacology and Toxicology, Queen's University, Kingston, Ontario, Canada K7L 3N6.*

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## ABSTRACT

As developing nations face dramatic population increases, demands for more and better quality food and the attraction of international trade in the global agricultural marketplace, chemical pesticide use will continue to rise, with concomitant increases in acute and chronic intoxications in the agricultural workforce. It is imperative that governments develop a "philosophy" concerning the importation, manufacture, registration and use of these chemicals, frequently the nonpatented, inexpensive and highly toxic agents banned or restricted in industrialized countries. Pesticide misuse/abuse and adverse health consequences will continue to plague developing nations until there is a political will to allocate adequate resources, both monetary and personnel, to develop an infractructure for control of and education about pesticides.

The "philosophy" must include a component to initiate and support training programs for agricultural workers, educating them about the hazards, handling and safety of these chemicals. Such programs could be operated through governmental extension services or through regional universities.

Keywords : Pesticide, developing countries, toxic agent, agricultural workforce.

Many developing nations are experiencing transitional phases, with migration of agricultural workers to urban centers in search of better-paying jobs, leaving fewer people responsible for raising traditional foods for themselves and for this new industrialized workforce. In addition, many regions capable of growing two or even three crops per year are being encouraged to enter the global agricultural market, providing fresh fruits and vegetables off-season to countries in more temperate climates with shorter growing seasons. Countries in South and Central America, Africa and Southeast Asia are becoming important "bread baskets" to the world, shipping non-traditional export produce (NTEPs) to other countries, thereby earning more farm income and much-needed international trade credits for their countries (Ecobichon, 2001).

The change from an agrarian culture to a new industrialized society results in a concomitant demographic shift in population to urban centers. A good example of this phenomenon was published for Taiwan (Chen and Huang, 1997). Between 1951 and 1992, the number of people involved in agriculture declined from 56% to approximately 12%, while those in the industrialized sector rose from 16% to 40%. Such changes create several problems: (1) fewer people are left on the farms; (2) these tend to be older and/or have less education; (3) they must adapt to new agricultural practices in order to achieve food production goals. New agricultural practices will include: intensive planting; the use of improved and even genetically modified strains of crops; mechanized rather than labor-intensive practices; greenhouse operations where environmental control can improve yields; and an increased reliance on chemical fertilizers and pesticides (fungicides, herbicides, insecticides) not used as extensively in traditional agriculture.

The above problems are further complicated by unrestrained population growth in developing nations. Osborne (1997) has commented on this aspect, e.g. "the dramatic increase in Thailand's population in the past two decades has begun to strain that country's current agricultural resources." Cambodia's population is expected to double by 2020 (Osborne, 1997). In recent, private discussions with officials in Laos, concerns about self-sufficiency in food were raised since the current population of 5.5 million is expected to reach 10 million by 2025 (Personal communication).

None of the above problems can be solved without the increased use of fertilizers and pesticides, introducing predictable environmental and produce contamination accompanied by real and potential adverse health effects in the agricultural workforce, their families as well as the local and global consumers. An example of increased pesticide use is shown in Figure 1, the data being for the Gaza Governates (Safi, 2002). Typical of other jurisdictions, dramatic increases in insecticide, fungicide, herbicide and nematicide use have occurred between 1990 and 1999 in an arable area of approximately 245 $km^2$ densely populated by 1.0 million inhabitants living and working in agriculture. Crop use includes vegetables, citrus fruit, olives and grapes.

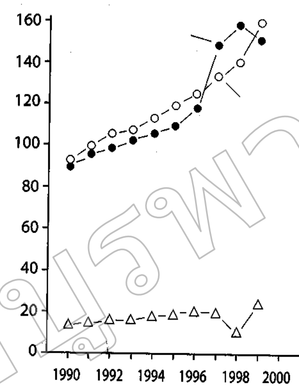


**Figure 1.** Increasing pesticide use in a developing country - Gaza Governates - 1990-1999 (Data from Safi, 2002).

The consumption of pesticides by developing nations is quite modest compared to the U.S.A., but these figures are now out of date. The information in Figure 2, from 1994, does not reflect present day use (Ecobichon, 2000; FAO, 1994). For example, the amount of pesticides imported into Vietnam has risen steadily from 20,000 to 42,000 metric tons between 1991 and 1998 (Vietnam Botanical Protection Agency, 1999). The data in Figure 2 does not reflect the classes of pesticides used. In industrialized, mechanized agriculture, the predominant class of agents would be herbicides whereas, in most developing countries, the bulk of agents used are still insecticides, given that insect pests create more immediate problems in crops. In China, insecticides account for the highest proportion (60%) of the total pesticide usage (He and Chen, 1999). In Vietnam, 80% of the product volume used is insecticides (Tennenbaum, 1996). Insecticides comprise 76% of pesticides used in India (Saiyed et al, 1999). However, the shift from labor- to machine-intensive agriculture, employing fewer people has created a "need" for herbicides. This occurred in the late 1980s in Thailand and the changing patterns of herbicide, insecticide and fungicide use between 1987 and 1996, shown in Figure 3, demonstrate the necessity for herbicidal application to control unwanted, invasive vegetation which was removed traditionally by hand (Thapinta and Hudak, 2000).

The data shown in Figure 2 also does not reflect the type of agents used in developing countries. Invariably, the pesticides used tend to be "older", nonpatented, least expensive, more clinically toxic and environmentally persistent agents manufactured in-country or formulated from active ingredients imported from countries in the region having chemical-synthesizing capabilities. Purity is a major concern with these imported chemicals. Most of them have been banned or their use severely restricted in "western" or European countries but are freely available on the world market, often forming part of the package of foreign aid.

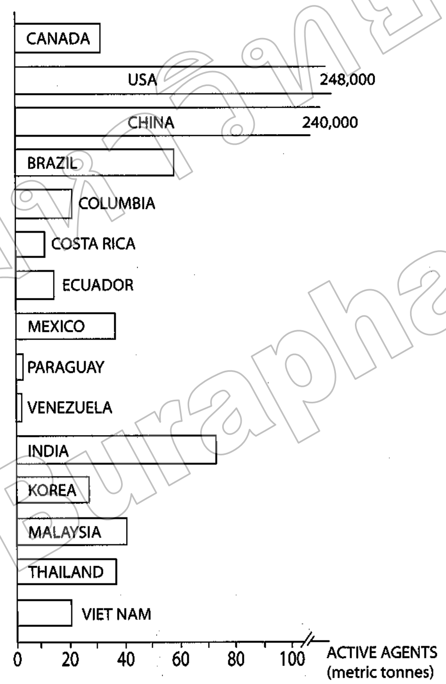


**Figure 2.** Pesticide consumption for 1994 in some developed and developing nations. The bars represent the active ingredients presented as metric tons (one metric ton = 1,000 kg). These data are no longer valid, most developing countries have increased usage of these agro-chemicals since that time. (FAO, 1994).

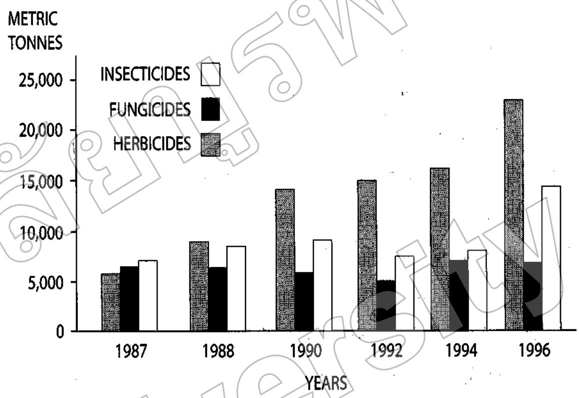


**Figure 3.** Changing patterns of agricultural practices reflected in the amount(s) of specific pesticides (metric tonnes of active ingredients) imported into Thailand, 1987-1996 (Data from Thapinta and Hudak, 2000).

Examination of recent literature reveals that the major proportion of human, acute toxicities related to pesticides comes from developing nations. Approximately 3 million cases of acute, severe poisonings (including suicides) have been estimated worldwide annually, matched by a greater number of unreported, mild-to-severe intoxications and some 220,000 deaths of which 99% occur in developing countries (WHO, 1990). These summaries may not reflect the actual situation in developing nations. Estimates suggest that some 60% of afflicted individuals never seek medical attention since doing so would mean taking time from work, something that agricultural workers cannot afford to do. Jeyaratnam (1982), in a national survey in Sri Lanka, reported an incidence of 100,000 persons admitted to hospital for acute intoxications annually with almost 1,000 deaths, out of a population of 12 million. In Thailand in 1983, an estimated 8,268 pesticide-related intoxications occurred within an agricultural community of 100,000 workers (Boon-Long et al., 1986). In 27 provinces of China in 1993, there were 52,278 cases of acute pesticide poisoning with 6,281 deaths (He and Chen, 1999). The data in Table 1 illustrates the problems associated with the increased use of different classes of pesticides in Chile over three years. Whether one examines reports from Costa Rica (Leveridge, 1996), Nicaragua (McConnell and Hruska, 1993), Taiwan (Yang et al., 1996)., or Thailand (Thapinta and Hudak, 2000), the majority of intoxications (intentional and accidental) can be attributed to the organophosphorus and carbamate ester insecticides, with the exception of the herbicide, paraquat, an agent of apparent choice in suicides. He and Chen (1999), have reported that acute organophosphorus (OP) ester poisoning accounts for 78.8% of the total pesticide poisonings in China, 69.1% in Sri Lanka and 53.6% in Malaysia. It is perhaps important to note that, in China's experience, a higher risk of acute poisoning has occurred in individuals exposed to organophosphorus esters combined with other insecticides that in those exposed to a single organophosphorus insecticide (He and Chen, 1999). This particular problem arises as a consequence of insect resistance to single agents and the increasing use of combinations of insecticides, e.g. more than 600 preparations of an organophosphorus compound with another organophosphorus agent, a carbamate or a pyrethroid ester being marketed in China (He and Chen, 1999).

**Table 1.** Reported pesticide-related intoxications in the Chilean agricultural workforce.

| **Chemical class** | **Number of intoxications** | | |
|---|---|---|---|
| | **1995** | **1996** | **1997** |
| Organophosphorus | 75 | 199 | 293 |
| Carbamates | 18 | 39 | 31 |
| Pyrethroids | 17 | 24 | 35 |
| Phenoxyacetic acids | 8 | 4 | 4 |
| Bipyridyls | 4 | 14 | 17 |
| Organochlorine insecticides | 3 | | |
| "Others" | 32 | 103 | 10 |
| Mixtures | 17 | 89 | 44 |
| Totals | 147 | 476 | 56 |

* Data obtained from ISP, Subdepartment of Occupational Medicine annual reports on intoxications in the workforce.

The introduction of enhanced food production under vinyl or glass greenhouse conditions presents significant new problems to the workforce. Given the hot, humid, closed environment of greenhouses, pesticide aerosols remain suspended for a considerable time thereby influencing the re-entry intervals for workers returning to the sprayed area. Episodes of acute intoxication are frequently reported due to both dermal and inhalation exposure on re-entry (Machera, et al., 2002). One study from Korea did not reveal any relationship between working in this environment and pesticide exposure (Sohn and Choi, 2001). The authors suggested the more careful use of lower doses of the agents as reasons for the absence of acute toxicity. However, Lee et al. (1994) showed that vinyl-house workers used much more pesticides, toxicity being seen in male workers. Other immediate adverse health effects include asthma, allergic alveolitis and dermatitis (Illing, 1997). Potential health parameters, only beginning to be studied, now include infertility (both males and females), changes in conception delay, miscarriages, neurological and neurobehavioral development, cytogenetic (micro nuclei) changes and alterations in the male/female birth ratio (Illing, 1997; Lucero et al., 2000; Petrelli and Figa-Talamanca, 2001).

One must carefully "tease out" the occupational exposures (including home/garden use) from the total exposures since the statistics often include the intentional, suicidal data. Table 2 shows data for Southeastern Asia and Central America, the significant differences between occupation-related intoxications and suicides being noted for the Latin American countries (He and Chen, 1999). Presumably, the low incidence of suicides in Costa Rica and Nicaragua is associated with the religious abhorrence of taking one's own life. A recent, public health study of hospital pesticide poisoning data from Thailand revealed that, of some 4,536 chemical intoxications, 4,171 (91.9%) involved pesticides (Silkavute, 2002). Of a representative 1,416 cases, 849 (59.96%) were intentional, 413 (29.2%) were occupational, 129 (9.11%) were accidental, while 25 cases were of uncertain or unknown etiology.

**Table 2.** Pesticide-related occupational and suicidal poisonings in developing countries.*

| Country | Occupational | Suicidal |
|---|---|---|
| Indonesia | 1.9% | 62.6% |
| Sri Lanka | 31.9% | 36.9% |
| Malaysia | | 67.9% |
| Thailand | | 61.4% |
| China | 17.8% | 82.2% |
| Costa Rica | 67.8% | 6.4% |
| Nicaragua | 91.0% | 1.0% |

* He and chen (1999)

Considering only the occupational exposures, one can readily identify those individuals at greatest risk who need specialized training in appreciation of the toxic nature and handling of these pesticides. As is shown in Table 3, comprising data presented by Silkavute (2002) for 363 occupational exposures, intoxications related to field application were predominant, other pesticide-related activities accounting for only 15.1% with household application responsible for 5.2% of intoxications. Characteristically, the majority of the intoxications involved organophosphorus insecticides followed by those related to dipyridyl (paraquat) and then those associated with carbamate insecticides. This pattern is not unlike that observed for other poison control jurisdictions except in "western" countries where paraquat is not used extensively.

While developing countries are showing a high level of concern for the acute intoxication situations, little attention is given to chronic effects of low-to-moderate level exposure on a seasonal or annual basis for many years. Chronic intoxication is occurring now in many countries but is not being scrutinized in relation to teratogenesis, carcinogenesis, reproductive outcomes (infertility, defects in spermatozoa or ova, miscarriages and spontaneous abortions) and neurotoxicity. Epidemiological studies in developing countries are difficult to conduct since, rarely, is there a reporting system in place; no established infrastructure for collecting and collating data exists; numerous factors (diet, lifestyles, other chemicals) confound the results; and there is a paucity of trained personnel. Guillette et al. (1998) in her study of preschool (4-5 years old) Yaqui children in northwestern Mexico, showed that those routinely exposed to pesticides around farms, demonstrated decreases in stamina, gross and fine eye-hand co-ordination, 30-minute memory and an inability to draw people, neurological deficits not seen in unexposed Yaqui children. The conduction of such studies in developing countries could "prove" associations between pesticides and adverse health effects since, unfortunately, exposures are much higher, the consequences of unregulated use of agricultural chemicals. It is imperative that developing nations do not ignore the chronic but subtle effects of pesticides.

The short-term solution to pesticide problems is legislation. However, in many developing countries, pesticide legislation is rudimentary at best and few governments have developed definite "philosophies" pertaining to these chemicals, frequently importing or manufacturing whatever is needed to increase both home food production and export crop

**Table 3.** Occupational pesticide exposures in Thailand grouped by agricultural activities.*

| Occupation | Cases | Percent |
|---|---|---|
| Field application | 289 | 79.6 |
| Mixing/Loading | 29 | 7.9 |
| Field re-entry | 26 | 7.2 |
| Household | 19 | 5.2 |

* Data from Silkavate (2002)

yields. Legislation is totally inadequate without enforceable regulations. Regulations are the necessary "teeth" to enforcing any laws but require a bureaucratic infrastructure necessary for inspection of chemical purity, label requirements, specific crop use, storage and handling, application, environmental contamination, food residues, etc. All of this requires manpower trained in various disciplines capable of investigating and enforcing problems contravening the regulations, even up to and including legal action. One way of circumventing some of these problems is to make full use of international agencies such as the United Nations (UN), the World Health Organization (WHO), the Food and Agricultural Organization (FAO), the International Labour Organization (ILO), to which most countries belong and to which representatives are sent. These bodies have extensive databases, much of it available directly on-line. Additional sources of freely available pesticide monographs, etc. can be accessed from the International Agency for Research on Cancer (IARC), the International Registry for Potentially Toxic Chemicals (IRPTC) and the FAO Joint Meeting on Pesticide Residues (JMPR).

The long-term solution to pesticide problems is education. Who bears the responsibility for training the people remaining on the farms about new agricultural practices including how to use unfamiliar chemicals safely? Certain government departments might be willing to initiate training programs, but their mandates do not include education. Government departments with responsibilities for pesticides have too few trained agronomists, chemists, biologists, entomologists, mycologists, engineers, etc. in extension service roles at the local level to gather and analyze samples, to advise farmers, to educate and work with those using pesticides, to initiate integrated pesticide management programs and to promote personal and family protection. Effective information and technology transfer is the key to reducing a broad range of pesticide-related problems, but this requires a departmental or inter-departmental infrastructure that is currently nonexistent in many countries.

In some developing countries, there is a surprising amount of pesticide information available, even in the appropriate language, but it is spread out among different departments and dissemination is poor. Frequently, one department is unaware of what information another department has, and there is little inter-departmental co-operation to pull information together. In other countries, the amount of pesticide information is limited, and people appear to be unaware of the resources available through the above-mentioned international organizations, much of it freely accessible on internet sites in various formats.

Is there a role for universities in pesticide-related education? Yes! A systematic collection of a nation's available pesticide information would make a challenging graduate thesis, but there could be much more, even taking a role in training. In some of the more progressive countries, field extension services are already offered where appropriate faculties (agriculture, environmental sciences, medicine, engineering, etc.) are based on campuses and serve the neighbouring agricultural region. Out of local problems arise opportunities to conduct various types of research projects. However, much more interaction could be possible except for the ever-present shortage of trained manpower. Training programs for farmers must be mobile - going to them at times convenient to their agricultural activities, making use of pamphlets, videos, presentations to all of the agricultural community (farmers, wives, children), then re-enforcing the messages of pesticide handling, safety in use, pest management prectices and environmental contamination.

Pesticide misuse and associated adverse health effects will continue to plague developing countries in the next decades until adequate national resources are committed to develop the infrastructure necessary to bridge the void between policies and ultimate use of these chemicals. Effective information transfer is the key to many of these problems, but there has to be the political will to address the issues.

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