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# Reducing acute poisoning in developing countries—options for restricting the availability of pesticides

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**Abstract**

Hundreds of thousands of people are dying around the world each year from the effects of the use, or misuse, of pesticides. This paper reviews the different options to reduce availability of the most hazardous chemicals, focusing on issues in developing countries. Emphasis is placed on the fatal poisoning cases and hence the focus on self-harm cases. Overall, it is argued here that restricting access to the most hazardous pesticides would be of paramount importance to reduce the number of severe acute poisoning cases and case-fatalities and would provide greater opportunities for preventive programmes to act effectively. The aim should be to achieve an almost immediate phasing out of the WHO Classes I and II pesticides through national policies and enforcement. These short-term aims will have to be supported by medium- and long-term objectives focusing on the substitution of pesticides with safe and cost-effective alternatives, possibly guided by the establishment of a Minimum Pesticide List, and the development of future agricultural practices where pesticide usage is reduced to an absolute minimum. Underlying factors that make individuals at risk for self-harm include domestic problems, alcohol or drug addiction, emotional distress, depression, physical illness, social isolation or financial hardship. These should be addressed through preventive health programmes and community development efforts.


*Keywords:* Acute poisoning; Pesticides; Self-harm; Developing countries; IPM

## 1. Acute pesticide poisoning: extent of the problem

The first global estimates of the extent of pesticide poisoning were published in 1990 by the World Health

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Organisation (WHO, 1990). Based on extrapolations from limited data, it was estimated that 3 million cases of pesticide poisonings occurred world-wide annually with 220,000 deaths, the majority intentional.

### 1.1. Self-poisoning

The WHO estimates, based on 2001 data, that 849,000 people die globally from self-harm each year (WHO, 2002). How many of these cases are a result of poisoning with pesticides is not known. However, poisoning is the commonest form of fatal self-harm in rural Asia, accounting for over 60% of all deaths (Somasundaram and Rajadurai, 1995; Phillips et al., 2002; Joseph et al., 2003) and is of far greater importance than hanging, and other physical forms of self-harm. Furthermore, a review of poisoning studies reveals that pesticides are the commonest means of self-poisoning in many rural areas and associated with a high mortality rate (Eddleston, 2000). A recent national survey in Bangladesh showed that 14% of all deaths (3971 of 28,998) of women between 10 and 50 years of age were due to self-poisoning, the majority with pesticides (Yusuf et al., 2000). The problem is particularly severe in Sri Lanka (Berger, 1988; van der Hoek et al., 1998) where pesticide poisoning was the commonest cause of hospital death in six rural districts during 1995 (Sri Lankan Ministry of Health, 1997). In many countries, the widespread availability of acutely toxic pesticides used in agriculture has made selection of pesticides as the agents of choice for self-harm well known to both health care workers and public health authorities (Nalin, 1973; Kasilo et al., 1991; Daisley and Hutchinson, 1998).

### 1.2. Occupational and accidental poisoning

The significant problems of human illness and death that follow occupational and accidental exposure to pesticides have been well documented (Forget, 1991; Garcia, 1998). Occupational illness is common because it is impractical and expensive to use safety equipment in the humid tropics (Dinham, 1993; Wesseling et al., 1997; Karalliedde et al., 2001). Safety instructions on containers are often written in unfamiliar languages, many farmers are illiterate, and the instructions themselves impossible to follow. After coming into contact with pesticides it is difficult to ‘wash off at once’ when there is no water available and even more to ‘see a doctor immediately’ when the nearest is many miles away (Bull, 1982; Dinham, 1993).

The irrelevance of workers’ health to some agricultural employers in the developing world—where sick employees can be summarily dismissed and new workers taken on—will continue to impede better pesticide handling. The pesticide practice of farmers can be frankly dangerous—observed practices include spraying without any safety equipment for far longer than recommended periods and even tasting pesticides to check for the correct mix (Dinham, 1993). Different pesticides are frequently mixed together by farmers to make ‘more effective’ pesticides, ensuring that subsequent medical management of poisoned patients is particularly complicated.

A response has come from the International Labour Organisation (ILO) which, through its programme on occupational safety and health in agriculture, has focused on the 50% of the world’s labour force employed in agriculture. The ILO supports the establishment and implementation of national strategies for the improvement of occupational safety and health of rural workers (ILO, 2000). Yet the widespread practice of child labour continues to put children, particularly adolescents, at serious risk of occupational poisoning.

A lack of facilities for safe storage and disposal ensures frequent accidental poisonings, particularly among small children (Bull, 1982; Haynes, 1985). Similar to self-poisoning, a major factor in paediatric poisoning is access to the poison. Children in industrialised countries ingest common and relatively safe medications, such as analgesics (Pearn et al., 1984). In contrast, the wide availability of toxic pesticides in the developing world produces a far higher accidental death rate in children (Singh et al., 1995).

## 2. An approach to reducing pesticide poisoning in the developing world

Murray and Taylor (2000) have proposed a policy and strategic approach to deal with issues of occupational pesticide poisoning in developing countries. The strategy builds upon the classic industrial hygiene ‘hierarchy of controls’ (Plog, 1996; Cole et al., 2002) going from highest priority, most effective to lower priority, least effective.

### 2.1. Most effective

1. Eliminate more highly toxic compounds;
2. Substitute with less toxic, equally effective alternatives;
3. Reduce use through improved equipment;
4. Isolate people from the hazard;
5. Label products and train applicators in safe handling;
6. Promote use of personal protection equipment;
7. Institute administrative controls.

### 2.2. Least effective

The first set (1–3) includes engineering controls. They include complete elimination of the small number of highly to extremely toxic pesticides and their systematic substitution with less toxic products based on an ongoing review of evidence, often after the introduction of alternative pest control approaches. They also include modifications to equipment, such as low flow spray nozzles or formulations, to reduce use or exposure directly.

The second set (4–6) involves reducing population exposure. In rural settings of the developing world isolation might involve locked storage cabinets for pesticides. Activities focusing especially on the occupational poisonings include labelling and training often implemented in conjunction with the promotion of personal protective equipment (Cole et al., 2002). Similarly, the provision of appropriate exposure monitoring and systems to evaluate the effects of training programmes would form part of this.

The final step is setting up administrative controls. These controls do not reduce population exposure but introduce a system in which applicators take turns applying pesticides. This may therefore reduce individual exposures in occupational settings.

The hierarchical approach proposed by Murray and Taylor (2000) might also have beneficial effects on the number of acute intentional pesticide poisoning cases. However, it will need to be adapted to address the issues of case management in hospital settings, programmes aimed at counselling for mental health problems, and improving underlying social issues at community level (Roberts et al., 2003).

Overall, we argue here that restricting access to the most hazardous pesticides will be of paramount importance in reducing both the number and case-fatality proportion of acute poisoning cases, and to provide greater opportunities for preventive programmes to act effectively. We acknowledge that comprehensive active clinical surveillance versus passive hospital-based surveillance, would identify more non-fatal acute poisonings occurring in the occupational and accidental groups (Cole et al., 2000). However, in this paper emphasis is placed on the fatal poisoning cases and hence the focus on self-harm cases.

The different options available to reduce availability of the most hazardous chemicals are reviewed in this paper, focusing on issues in developing countries. The paper builds on an earlier paper published by Eddleston et al. (2002) and discusses four different avenues with potential for reducing use and availability of pesticides important for acute poisonings:

- Voluntary guidelines, Safe Use Initiatives, and international policy instruments;
- Changes in farming practice: integrated pest management (IPM) and plant biotechnology;
- Direct restrictions of pesticide use;
- A Minimum Pesticide List.

## 3. Voluntary guidelines, Safe Use Initiatives, and international policy instruments

### 3.1. The International Code of Conduct on the Distribution and Use of Pesticides

In the early 1980s, a debate about the effects of uncontrolled pesticide use on health in the developing world grew around the world. International organisations, national governments, and industry all responded to these concerns with a series of non-binding proposals.

The major response was the production of the *International Code of Conduct on the Distribution and Use of Pesticides* in 1985 by the Food and Agriculture Organisation (FAO) of the United Nations. In November 2002, FAO adopted a revised Code of Conduct incorporating concerns and experiences generated since the drafting of the previous version. The Code attempts to rationalise the use of pesticides and reduce the health and environmental risks associated with pesticides (FAO, 2002).

Its stated aim is to establish:

> . . . voluntary standards of conduct for all public and private entities engaged in or associated with the distribution and use of pesticides, particularly where there is inadequate or no national legislation to regulate pesticides. (Article 1.1)

In particular, it wished to ensure that the benefits derived from the use of pesticides be achieved without significant adverse effects on people or environment (Article 1.3).

The new version of the Code of Conduct adapts a 'life-cycle' concept to address all stages from development of products to the final disposal of containers and products. Manufacturers are requested to supply only pesticides of adequate quality, packaged and labelled as appropriate for each specific market, and to retain an interest in the product as far as the ultimate consumer, keeping track of uses and the occurrence of problems requiring changes in labelling, directions for use, packaging, formulation or product availability. In particular, the Code stated that

> pesticides whose handling and application require the use of personal protective equipment that is uncomfortable, expensive or not readily available should be avoided, especially in the case of small-scale users in tropical climates. (Article 3.5)

The Code further stipulates that highly toxic and hazardous products (such as WHO Classes Ia and Ib) may be prohibited for importation, sale and purchase if other control measures or good marketing practices are insufficient to ensure that the product can be handled with acceptable risk to the user (Article 7.5). Many countries do not live up to these standards and if the Code were to be followed this would prohibit the use of Class I pesticides in many developing countries. This relates especially to occupational exposure since the required safety equipment is expensive and cumbersome in the tropics, and almost never worn.

National governments were called upon in the Code of Conduct to

> have the overall responsibility to regulate the availability, distribution and use of pesticides in their countries and should ensure the allocation of adequate resources for the mandate. (Article 3.1)

In spite of international efforts to support developing countries in achieving the capacity to implement and supervise the Code of Conduct, many developing countries still do not have this necessary oversight capacity.

In the second global survey finalised in October 1994 to assess the state of implementation of the Code of Conduct, it was concluded that although progress had been made towards compliance with various provisions of the Code, especially in the Asia and Pacific region there is a continuing need by governments for assistance. More than half the national agencies responding to the questionnaire indicated a need for technical assistance and increased government support to strengthen their national capacities and infrastructures necessary to operate effectively their pesticide control schemes (FAO, 1996).

The crucial role of national government capacity in enforcing the Code was explicitly acknowledged by the then Director of the FAO, in his introduction to the Code in 1985 (FAO, 1990):

> In the absence of effective pesticide registration processes and of a governmental infrastructure for controlling the availability of pesticides, some countries importing pesticides must heavily rely on the pesticide industry to promote the safe and proper distribution and use of pesticides. In these circumstances, foreign manufacturers, exporters and importers, . . . , must accept a share of the responsibility for safety and efficiency in distribution and use.

Unfortunately, in spite of increasing support to improve the capacity of national agencies since mid-1980s, policing of the Code is still so severely hampered by the lack of resources and political will that there is as yet no effective mechanism to enforce it or publicise violations. Further, the Code of Conduct does not give direct attention to the issue of self-harm with pesticides and therefore fails to provide policy guidelines or assign responsibilities on this complex issue. Also, the fact that the revised Code does not directly call for an elimination of the most hazardous pesticides and that adherence to the great majority of the articles in the Code is voluntary will likely reduce its overall effect on the number of deaths from acute poisoning.

### 3.2. Efforts by producers of pesticides

A number of producers of pesticides have been involved in attempts to limit unsafe pesticide use. The

Global Crop Protection Federation (GCPF) (2003), now renamed CropLife International established by the pesticide industry aimed to:

> communicate and promote Industry positions on key issues . . . (and) . . . co-ordinate actions to face emerging challenges. (www.gcpf.org, 2003)

However, it also aimed to:

> provide, through the GCPF Safe Use Initiative, training and guidance to achieve significant progress in the safe, effective and environmentally responsible handling and use of crop protection products. (www.gcpf.org, 2003)

This initiative set up pilot projects in Kenya, Guatemala and Thailand. Audit of the Thai project found an increased awareness of safety issues by local farmers, but little improvement in their actual use of pesticides (Ellis, 1998). The industry has described its Guatemalan project as a resounding success since the number of pesticide poisoning cases nationally were noted to fall at the same time as its Safe Use Project (AGREQUIMA & GIFAP, 1995). However, more recent analysis has noted the poor quality of the data linking the fall in poisonings to the Safe Use Project and raised doubts of a causal link (Murray and Taylor, 2000). A 7-year study by Novartis, now Sygenta and formerly Ceiby-Geigy and one of the largest pesticide producers in the world, found that 'safe use of pesticides' interventions in Latin America, Africa and Asia were expensive and largely ineffective, particularly with smallholders (Atkin and Lesinger, 2000).

The industry has for years worked with both FAO and national governments to remove and destroy stockpiles of pesticides left in the tropics reducing the overall availability of large quantities of hazardous chemicals (FAO, 1997). However, the effect of these activities on the availability at household level needs further documentation.

### 3.3. International conventions

Recent conferences have produced conventions on *Prior Informed Consent* (PIC) (FAO, 1990) and *Persistent Organic Pollutants* (POP) (UNEP, 2001). The former serves as an early warning system to notify developing countries of hazards and limit export of toxic pesticides by requiring exporting countries to receive prior approval from the recipient country. The latter aims to phase out production and use, or otherwise eliminate, 12 persistent organic pollutants, 9 of which are pesticides.

Both conventions have the potential for reducing availability of a number of highly toxic compounds if the conventions are followed up, resources committed and agreements adhered to. Importantly, the PIC Convention transfers the Article 9 of the Code of Conduct for the Distribution and Use of Pesticides from a voluntary procedure into a legally binding mechanism. This includes the exchange of information from one national regulatory authority to another if actions have been taken to ban or severely restrict a pesticide in order to protect human health (Article 9.1.2.1).

Other international policy instruments provide more general policy guidelines focused on the environmental, biodiversity and long-term implications linked to occupational exposure and food residues, including the *Convention Concerning Safety in the Use of Chemicals at Work*, the *Convention on Biological Diversity and the Agenda 21 of the United Nations Conference on Environment and Development (Chapter 19)*. The policy instruments may not directly or in the short term reduce acute poisoning cases but will overall encourage the development of agricultural production approaches and pest control initiatives based on reduced pesticide use.

However, it is possible that some of the conventions and international agreements on pesticides may imply trade-offs between environmental concerns and human health risk. In the process of phasing out some of the most environmentally unfriendly products they may be replaced with chemicals with a high human toxicity, e.g. persistent organochlorine compounds with carbamates in malaria control programmes. Similarly, the opposite may occur as chemicals assessed to be relative safe for occupational use may have negative effects on the environment and biodiversity, e.g. substitution of pyrethroids for organophosphates. Clear policy statements are needed to indicate approaches that simultaneously meet both objectives.

## 4. Changes in farming practice: IPM and plant biotechnology

### 4.1. Alternative pest control methods

In an attempt to slow the development of pest resistance, improve the financial basis for agricultural production, and improve the health of the farming population, systems of IPM have been introduced around the world. IPM is an ecological approach to plant protection, which encourages the use of fewer pesticide applications. The most toxic pesticides and those with greatest local resistance are identified; their use is then restricted and a regimen of decreased applications implemented based on field monitoring and physical and biological control methods, in order to protect natural enemies of the pests. It is now widely recognised that IPM contributes significantly to the productivity and profitability of agricultural systems in an environmentally sound and equitable manner (Kenmore, 2002). For example, the Agenda 21 action plan, formulated by the United Nations 'Earth Summit', convened in Rio de Janeiro in 1992, identified IPM as a key element in sustainable agricultural development.

In Sri Lanka, IPM trained farmers used less pesticides and had less signs of poisoning than farmers not trained in IPM (Smit et al., 2003). This was also documented in a study in Nicaragua which showed that after 2 years, the IPM trained farmers used fewer pesticides, spent less money on pest control, made higher net returns, and suffered less exposure to cholinesterase-inhibiting pesticides than farmers who did not receive IPM training (Hruska and Corriols, 2002).

The effects of IPM training on the incidence of self-harm still needs to be documented but there is good reason to believe that with the implementation of a successful IPM programme, including the phasing out of the most hazardous pesticides, proper storage, and overall reduced use and availability the number of intentional, as well as unintentional cases will be reduced. The new Code of Conduct calls upon governments to give more emphasis to IPM and to make a concerted effort to develop and use it more than previously.

The pesticide industry states that it now fully supports a policy of restricted pesticide use within an IPM programme (CropLife, 2001a). However, the industry's view of IPM differs from that of many workers in the field in that it perceives a clear need for pesticides in most situations (CropLife, 2001b). Furthermore, its practice of paying pesticide salespeople on a commission basis, with increased sales being rewarded with increased earnings, is unlikely in practice to encourage a limited use of pesticides.

If IPM is ever to be more widely used, incentives for pesticide use will have to be removed. National governments and donor agencies will also need to reconsider their policies. Two World Bank studies have shown that many developing countries and donor agencies limit IPM by providing financial incentives for the use of pesticides via subsidising their import, domestic manufacture and marketing (Wiebers, 1993; Farah, 1994). These subsidised prices distort the cost of various pest control methods and make the use of agrochemical economically preferable to non-chemical methods. A review of all World Bank projects performed by the Pesticide Action Network North America for the period 1997 and 2000 found that few had made any mention of IPM (Watterson, 2001).

The FAO, United Nations Environment Program (UNEP) and The World Bank have helped establish IPM initiatives, such as the Global Integrated Pest Management Facility (2003) (www.fao.org, 2003). The Facility is developing the *Integrated Pest and Plant Management-2015* project which aims to promote IPM on a global scale by 2015 alongside a gradual phasing out of Class I and then Class II pesticides. This initiative is currently in its design stages but could provide a significant organisational support to IPM implementation on a large scale. This is important because the pace of implementation of IPM is still slow and in many countries the agricultural extension service is far from being able to reach all farmers.

### 4.2. Biotechnical advances

In addition or in combination with the promotion of IPM, technological advances in the field of plant biotechnology is seen by some as carrying a great potential for reducing pesticide applications without reducing yields (Dempsey et al., 1998; Sharma et al., 2002; Gerhardson, 2002). The first transgenetic insect-resistant crop was grown in the USA during

1994. Since then, there has been a rapid expansion in the farming with transgenic plants and various varieties are now grown in over 12 countries around the world. Deployment of insect-resistant crops has been associated with a 1 million kg reduction of pesticides applied for pest control in USA in 1999 compared with 1998 (Sharma et al., 2002).

Transgenic plants expressing insecticidal proteins from the bacterium, *Bacillus thuringiensis* (Bt), have been engineered into major crops that were grown on 11.4 million ha world-wide in 2000. Based on the data collected to date, the introduction of this new crop has resulted in a reduction in the use of insecticides (Shelton et al., 2002). However, the future promotion of genetically modified plants is debated internationally and fears have been expressed over the long-term environmental and public health consequences. In particular, issues related to intellectual property rights and the need to buy new seeds every year have been raised by farmers in developing countries (Bakshi, 2003).

## 5. Direct restrictions of pesticide use

### 5.1. Pesticide restriction programmes

WHO policies aim to reduce death rates by restricting the availability of poisons commonly used for self-harm (WHO, 1996, 1999, 2001). Physicians have taken a similar line, calling for the banning of particular pesticides that generate local clinical problems, e.g. paraquat in Trinidad and aluminium phosphide in India (Daisley and Hutchinson, 1998; Siwach and Gupta, 1995). A number of examples world-wide have shown that restricting the availability of highly toxic or locally popular pesticides can indeed be effective in reducing total death rates from self-harm.

Piola and colleagues recently showed that a national ban on the organophosphate parathion reduced the number of deaths reported to their poison centre in Rosario, Argentina (Piola and Prada, 1999; Piola et al., 2001). Between 1977–1985 and 1990–1994, 21 lethal pesticide poisoning cases were reported to the centre, including 15 adult cases of self-poisoning and 4 accidental cases in children, 17 of which were due to parathion. Due to the high number of deaths occurring nationally with this pesticide, it was banned throughout Argentina in 1994. The last death from parathion in Rosario was reported in 1995. There was subsequently a marked fall in the number of all deaths due to poisoning: from 16 in the first half of the decade to 4 in the second (Piola et al., 2001).

Parathion was also banned in Jordan during 1981 after studies showed that it was responsible for >90% of deaths from pesticides in the country. The total number of poisoning deaths undergoing autopsy in Amman fell from 58 in 1978 and 49 in 1980 to 28 in 1982 and 10 in 1984.

Paraquat was introduced to Samoa in 1974. Soon after, public health officials noticed a growing epidemic of self-poisoning (Bowles, 1995). The total suicide rate increased from 10/100,000 in 1974 to 28/100,000 in 1978 and 50/100,000 in 1982. Because of this epidemic, a community-based campaign was set up to reduce its use for self-harm. At the same time, however, imports fell temporarily due to financial problems. The suicide rate fell rapidly, mirroring the fall in imports, to 15/100,000 within 2 years. Interestingly, the suicide rate between 1984 and 1988, although much reduced at 15–20/100,000, was still more than 80% due to paraquat and has continued to rise since. Suicide with this pesticide had become the method of choice. The pesticide was never banned and remained the cause of around 80% of all self-harm deaths (Zinn, 1995). Banning paraquat is still the subject of active debate in Samoa today (Anon., 2001).

Since the late 1980s, the Sri Lankan government has taken an active role in determining which pesticides can be used in the country. By the mid-1990s, all Class I pesticides were banned in Sri Lanka. As a result, the number of deaths due to metamidaphos and other Class I OPs fell dramatically as documented for one district hospital (Roberts et al., 2003). Unfortunately, another highly toxic (although Class II) compound, the organochlorine endosulfan, then replaced the Class I OPs in agricultural practice. The number of self-poisoning deaths rose as endosulfan became more popular. Endosulfan was therefore banned in 1998 and deaths fell from 50 to 3 in the same district hospital over the next 3 years (Roberts et al., 2003). No single compound has since taken its place, but there is currently an increase in importance of WHO Class II OPs, such as dimethoate and fenthion. Sri Lanka is attempting to shift to less toxic pesticides in the hope that this will reduce the number of deaths from deliberate self-poisoning. Thus far, these attempts have been complicated by the replacement pesticides also being sufficiently toxic to cause deaths from self-poisoning. Compared to the early 1990s, there has been little overall effect—just switching from one form to another. Future attempts to ban pesticides must carefully predict the likely consequences of switching to another pesticide in agricultural and self-harming practice (Roberts et al., 2003).

Generally, occupational exposure to pesticides will lead to milder signs and symptoms than poisoning due to self-harm ingestion. However, a restriction of availability of pesticides might have prevented the epidemic of occupational poisoning cases seen in north-western Nicaragua during 1987 that followed the adoption of the Class I pesticides carbofuran and methamidophos (McConnell and Hruska, 1993).

An increased use of pesticides in the Philippines during the 1970s coincided with a 27% increase in mortality from non-traumatic causes among economically active men. The incidence in men between the age of 15 and 34 of stroke—a condition rare in this age group but which could be confused with some types of acute pesticide poisoning—also rose during this period but then fell by more than 60% in the 2 years following a ban on endrin (Loevinsohn, 1987).

A recent Chinese study concluded that a major component of preventive efforts to reduce acute poisoning in rural areas will be restricting the ready availability of pesticides. The authors pointed out that the ready availability of potent pesticides in homes of most residents makes this the preferred method of self-harm (Phillips et al., 2002). This study also supports the idea that not all people who die following acts of self-harm actually wish to die (Eddleston, 2000). In a district in Sri Lanka, peaks of fatal self-harm poisoning coincided with ploughing seasons. This was not because people were more determined in their self-harm attempts in this season but because it was the time when farmers use paraquat (Hettiarachchi and Kodithuwakku, 1989). Furthermore, the often impulsive behaviour linked with the ingestion of pesticides and the influence of alcohol during events makes it important to restrict pesticide availability at homes (van der Hoek and Konradsen, unpublished).

Overall, these studies suggest that limiting the availability of toxic pesticides will reduce the number of deaths from poisoning and the number of deaths from self-harm. A similar reduction in self-harm deaths has occurred in the UK, Japan, Australia and India following the replacement of barbiturates with benzodiazepines as the most common sedative prescription (Oliver and Hetzel, 1972; Proudfoot and Park, 1978; Lester and Abe, 1989; Singh et al., 1997). Restrictions on availability are currently being adopted by the Ministers of Health of eight Central American and Caribbean countries. These countries have agreed to ban the 12 most problematic pesticides in their region together with a list of 115 pesticides that are restricted in at least one of these countries (Murray and Taylor, 2001). The organisers of this approach—the PlagSalud initiative—hope to reduce pesticide poisoning in Central America by 50% by restricting the most toxic pesticides (Wesseling et al., 2001). No results are yet available.

## 6. A Minimum Pesticide List

Eddleston et al. (2002) have called for the establishment of an Essential or Minimum Pesticide List building upon the experiences achieved with the WHO's model Essential Drugs List (EDL). The WHO's model EDL was initiated in 1977 to support the rational use of pharmaceuticals (WHO, 1995). The Model List today contains some 300 pharmaceuticals that should satisfy the health needs of the majority of the people for the majority of the time.

In countries that have successfully used the Model List to develop their own essential drugs programme, it has led to better supply of important drugs, more rational prescribing and lower costs, and easier quality assurance, procurement, storage, distribution and dispensing (Hogerzeil et al., 1989; WHO, 2000). Training and drug information have become more focused; prescribers have gained experience with fewer drugs and are able to recognise adverse reactions more quickly and accurately. Essential drugs are usually cheap and procurement of fewer items in larger quantities has resulted in economies of scale.

The current situation with pesticides has some similarities with that of pharmaceuticals in the 1970s. Hundreds of active ingredients and thousands of formulations are available and promoted by both manufacturers and distributors as being essential for crop production. 'Rational use' with so many pesticides and competing claims is difficult. Perhaps lessons learned from the EDL could be applied to pesticides. While the EDL has not achieved ideal implementation, it has contributed to improved health care and proved to be a useful public health tool. Might an analogous model Pesticide List be equally useful? Since many argue that no pesticide is everywhere 'essential' and that further development of IPM will remove the need for most synthetic pesticides, the list would be a model Minimum, rather than Essential, Pesticide List.

The first task in producing such a Model List will be to identify the minimal use of pesticides within an IPM system. All the available active pesticide ingredients would then be tabulated, based on priorities determined by comparative efficacy across pests and ecological conditions, safety, convenience and cost. Direct cost and animal toxicity data are readily available but other data are less well developed and data less apparent. This is particularly true for the indirect costs of pesticides on human health and the environment. The toxicity of solvents, not just the active ingredient, will need to be considered as well as the environmental consequences of the use of pesticides considered safe for humans—e.g. although pyrethroids are relatively safe for humans, they are highly toxic to fish and crustaceans (WHO, 1991).

A template containing examples plus expert opinion and evidence would then be applied at the country level to create an area specific Minimum Pesticide List with a sense of local ownership. Implementation at the local level would be tailored to local needs and problems (e.g. a major self-poisoning problem with a particular pesticide). Analogous to second-line antibiotics in the EDL, reserve pesticides could be listed to deal with local problems of resistance.

The Model List would not be prescriptive but advisory, giving under-resourced governments basic information that should allow them to determine which pesticides are currently useful for their agricultural needs. Unbiased assessment and comparison of pesticides, using an explicit and transparent evidence-based approach, would provide an enormously useful tool for both governments and small-scale farmers.

While enforcement of legislation would still often be difficult, a significantly reduced number of pesticides should simplify this process. A Model List would allow legislators to decide which few pesticides should be used in their region and then actively register them; other pesticides would not be registered, removing a large number of obsolete and highly dangerous pesticides from circulation.

## 7. Discussion

Clearly, the four avenues of intervention outlined in this paper could each play a role in bringing down the problems associated with acute pesticide poisoning in developing countries. However, in spite of the successes of certain programmes in specific situations, the overall picture still looks bleak with hundreds of thousands of people dying around the world each year from the effects of the use, or misuse, of pesticides. The problem is urgent and at a level where interventions with an immediate effect will have to be given the highest priority. This therefore supports programmes and policies that call for a complete and immediate ban on the most hazardous pesticides. The evidence is strong, indicating an immediate and significant impact following the elimination of the most hazardous chemicals available at the household level. The aim should be to achieve an almost immediate phasing out of the WHO Classes I and II pesticides through national policies and enforcement. However, a national policy to ban specific pesticides requires international support in terms of exchange of information and enforcement of policies and may involve bilateral as well as multilateral organisations.

These short-term aims will have to be supported by medium- and long-term objectives focusing on the substitution of pesticides with safe and cost-effective alternatives, possibly guided by the establishment of a Minimum Pesticide List, and the development of future agricultural practices where the pesticide usage is reduced to an absolute minimum.

The proposed Minimum Pesticide List would be a major public health initiative requiring a global approach and co-ordination to be most effective. This would reduce duplication, encourage evaluation and maximise the use of previous evaluations of pesticides performed in the industrialised world. The WHO and FAO should develop a model Minimum Pesticides List in collaboration with other interested parties. The establishment of a model Minimum Pesticides List would need inputs from a number of international actors involved in risk assessment, monitoring of effectiveness and establishing guidelines, such as the International Program on Chemical Safety (IPCS) and the International Commission on Occupational Health and Pesticides (ICOH). However, critics of these international actors have shown that additional scientific scrutiny and increased independent input is needed, especially from the non-governmental organisations, to balance the representation from the chemical industry in these programmes (Watterson, 2001). Implementation of a List would also result in the identification of hazardous pesticides that should be banned or severely restricted through the POP and PIC conventions.

The success achieved with IPM by community groups, non-governmental organisations and government departments needs to be further promoted with the aim of reducing the availability of pesticides in the homes of farming communities. This will clearly require that economic incentive systems currently in place be changed to reduce the gains linked with the promotion and use of pesticides. The strongest incentive for a shift towards IPM approaches or other approaches requiring limited or no inputs of pesticides may come from the consumers in developed as well as developing countries. This could come about if consumers, through awareness campaigns, put pressure on the producers and national export organisations to produce agricultural produce with limited use of pesticides. In addition, strong farmer unions, especially in the plantation sector, may be in a position to place pressure on the management to give priority to health of the workers and the communities. Increased public awareness about the health problems associated with the use of pesticides may also place pressure on the industry to change marketing practices, distribute in less concentrated doses and to place the highest emphasis on the development of products that are less hazardous to human health. At a more specific level the industry may experiment more widely with the formulations allowing for the inclusion of emetics to the pesticides. Although there is currently no evidence for benefit from this approach.

The international efforts that are based on a voluntary approach, such as the Code of Conduct, may gain wide support but at the same time it seems clear that the industry is unable to self-regulate in the absence of effective government law enforcement. While some of these pesticides may be safely used for restricted tasks in the West, their uncontrolled use in a developing country context results in immense human suffering. Overall, the revision of the Code of Conduct is a step in the right direction but significant additional resources are needed to support government agencies in its implementation. Likewise, increased resources will have to be allocated to improve the surveillance and analysis of data on pesticide poisonings, including registration at both community level and at health facilities. Without an improved health information system it will be difficult to formulate specific guidelines and policies and the under-reporting of cases will continue to be a significant problem (PAHO, 2001; Murray et al., 2002).

The four general areas of interventions outlined in this paper focus on the reduction of availability and use of pesticides and it is argued that this will have a positive effect on accidents, self-harm cases and would result in less occupational and environmental exposure. However, for self-inflicted cases the situation is of course more complicated. Underlying factors that make individuals at risk for self-harm include domestic problems, alcohol or drug addiction, emotional distress, depression, physical illness, social isolation or financial hardship (Hettiarachchi and Kodithuwakku, 1989; Gautami et al., 2001; Stallones and Beseler, 2002). These various underlying courses should be addressed through preventive health programmes and community development efforts but many of these interventions would only show an impact in the long term.

Also, medical management needs to be improved (Eddleston, 2000) but this is difficult with the few resources available—case-fatality rates for pesticide poisoning in parts of rural Sri Lanka exceed 50% during some months (Eddleston et al., 1998) and case-fatality rates with aluminium phosphide or paraquat reach 70% in South Asia (Hettiarachchi and Kodithuwakku, 1989; Chugh et al., 1991). There are too many patients, too few doctors, too few drugs and ventilators, and too little good evidence about how to treat patients with overwhelming poisoning following ingestion of these highly toxic compounds (Eddleston, 2000; Eddleston et al., 2002). The upgrading of the health care services to improve case management and the preventive and social and mental health care programmes to reduce the number of self-harm cases needs to be implemented in support of the overall programmes aimed at reducing availability of pesticides.

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