Should DDT be Banned by International Treaty?

C.F. Curtis and J.D. Lines

The insecticide DDT has been an effective and affordable means of malaria control in many countries, but pressure for its use to be banned is mounting. Here, Chris Curtis and Jo Lines take a critical look at evidence that links house spraying by DDT with harm to the environment and human health, and stress the need for resources for alternatives to DDT to be made available to countries that would be affected by a DDT ban.

The World Wildlife Fund for Nature (WWF) and The United Nations Environment Programme, among others, are pressing to include DDT (dichlorodiphenyltrichloroethane) in the proposed treaty to ban persistent organic pollutants. They consider that there is sufficient evidence that DDT is harmful to the environment and/or human health and that the imminence of a ban would stimulate the development of alternatives to DDT. Many malariologists, however, argue that the evidence that house spraying with DDT is harmful is not very convincing, and that, in many areas, such spraying has been the only affordable means of controlling malaria (and visceral leishmaniasis where it is transmitted by endophilic sandflies). Countries that use or might use DDT have very low health budgets and, without providing the financial and other resources to replace DDT adequately, a DDT ban would endanger human health by causing further contraction in the already small proportion of the world's malarious areas in which there is any vector control.

DDT and vector control

Ninety percent of worldwide malaria morbidity and mortality occurs in tropical Africa, but there has been little mosquito control there in recent years. The few African countries with house spraying programmes include Ethiopia, Zimbabwe, Botswana, South Africa and the highlands of Madagascar (see Table 1); elsewhere, many relatively small programmes[1] using insecticide-treated nets (ITNs) have been set up in the past decade. During the 1960s and 1970s, some local field trials and pilot campaigns of house spraying in equatorial Africa using DDT or other organochlorines[2] were very successful, for example, in the islands of Zanzibar and Pemba, where malaria transmission is naturally extremely intense, DDT spraying reduced prevalence of malaria parasitaemia to <5%. This was an extraordinary achievement that has not yet been matched by ITNs. It is argued that African countries should not be denied the option of taking up house spraying with DDT, the most affordable insecticide, if, in the future, they can find the resources for it.

Apart from South Africa and Madagascar, it is from Asia, Europe and Latin America that there are reliable data showing the impact on vector-borne disease of energetic use of DDT, and, in several cases, the resurgences that have followed its partial or complete withdrawal (Table 1). Presumably, these resurgences are at least partly because the additional costs of using alternatives to DDT necessitated a reduction in the area covered by spraying. In India, partly because of the bad publicity created by the campaign against DDT, the percentage of householders allowing spraying of their houses has declined far below that achieved in the heyday of the Malaria Eradication Programme in the 1960s.

How harmful is DDT?

DDT was used in agriculture in the 1950s in far larger quantities than against malaria mosquitoes[10]. In fresh water, it was lethal to fish and it accumulated in food chains and harmed the eggs of attractive top predators such as peregrine falcons. Consequently, DDT has been banned since the 1970s for agricultural use in most countries. However, the extent of harm caused by the use of DDT indoors for malaria control is not clear; in particular, it seems unlikely to be an appreciable source of DDT in food chains and a link between DDT and ill health in humans has not been convincingly demonstrated (Box 1).

Who gets the benefit of the doubt?

Proponents of the DDT ban stress the precautionary principle, ie. a biologically active chemical should not be used until it has been proved to be harmless. However, one cannot prove anything to be totally safe as one can never exclude the possibility of unanticipated, rare adverse effects.

Opponents of the ban advocate a response based on weighing the known health costs against the known health benefits. This evidence, however, tends to be biased, because the benefits of DDT to malaria control are limited to some parts of the rural tropics, while the risks (if any) may be difficult to measure because they are scattered worldwide if, as WWF contends[12], DDT spreads from inside sprayed houses to the whole ecosystem.

Thus, there appears to be a conflict of interest. In malarious areas, where DDT-spraying remains the most cost-effective and practicable form of control, although human exposure to DDT is relatively high, it seems unlikely that any risks from this will outweigh the benefits of being protected against malaria. Therefore, a precautionary ban on DDT without adequate replacement would leave people in these areas less healthy than before.

However, a precautionary ban would appeal more to people in areas where there is no malaria or no attempt to control it with DDT. They may be exposed to low doses of DDT as a result of house spraying elsewhere, but they enjoy no antimalaria health benefits from DDT. If billions of people are exposed in this way, adverse health effects that are undetectably rare might still amount to an impressive number of deaths or

Chris Curtis and Jo Lines are at the London School of Hygiene and Tropical Medicine, Keppel Street, London, UK WC1E 7HT.
Tel: +44 171 927 2339, Fax: +44 171 636 8739,
e-mail: chris.curtis@lshtm.ac.uk

 0169-4758/00/$ – see front matter PII: S0169-4758(99)01605-1

Table 1. Summary of history of DDT and vector borne disease in seven countries

Country	Pre-DDT	Active use of DDT	DDT use restricted or eliminated	Ref.
India	*c.* 75 million malaria cases and 0.8 million malaria deaths per year; also many cases of VL[a]	In 1960s *c.* 18 000 tonnes of DDT used annually; malaria down to *c.* 100 000 cases, VL eliminated	7500 tonnes of DDT for use against malaria and VL in 1999–2000, >3 million malaria cases, VL reappeared	3
Sri Lanka	2–3 million cases and 80 000 deaths in 1934–1935 epidemic	DDT campaign reduced number of reported cases to 17 in 1963	*c.* 360 000 cases reported in 1994; DDT resistance – replaced by organophosphates and pyrethroids	4
USSR and successor states	Malaria as far north as Moscow and across southern Siberia, *c.* 3 million cases in 1940	Malaria virtually eradicated in 1950s and 1960s by DDT, bio-environmental control and case finding and treatment	*c.* 15 000 cases in Tadjikistan and in Azerbaijan in 1996 and return of transmission in Ukraine and Urals	5
Italy	Marsh draining and quinine reduced number of malaria cases to 55 000 in 1939	Malaria eradicated by a few rounds of DDT spraying in late 1940s	Eradication of transmission maintained despite many imported cases	5
South Africa	*c.* 22 000 malaria deaths in 1931–1932; malaria morbidity paralysed the sugar industry	DDT spraying from late 1940s until 1990s drove malaria back to frontier regions without evolution of resistance in vector	Switch to pyrethroids in mid-1990s, malaria still in frontier regions (*c.* 7000 cases and 30 deaths per year)	6
Madagascar	Malaria endemic in lowlands, epidemics in highlands since 1878	DDT in 1950s eradicated malaria in highlands; DDT use re-started in 1990s to bring malaria back under control	Spraying stopped in 1960s; *Anopheles funestus* population recovered and in 1988–1991 caused an epidemic which killed many thousands	7
Venezuela[b]	One million cases per year; malaria death rate up to 80 per 1000 during epidemics – higher than that caused by 1918 influenza epidemic	Malaria eradicated from developed parts of the country (eg. Sucre state) by DDT spraying in 1940s, 1950s and 1960s	*c.* 24 000 cases per year recorded in late 1990s (including *c.* 5000 in Sucre state), despite pyrethroid spraying	8

[a] Abbreviation: VL, visceral leishmaniasis.
[b] Experience of Venezuela apparently matched by six other Latin American countries, in contrast to Ecuador where DDT use has increased and malaria incidence has declined[9].

cases of ill health. The conflict of interest surrounding a precautionary ban is sharpened by the fact that the people who would be likely to be harmed by it are poor and powerless while the people who might benefit from it include the rich and influential.

Who will pay for alternatives?

As long as a switch to alternative methods of malaria control does not entail reduction in effectiveness or contraction of the area where vectors are controlled, it would be generally agreed that the switch is desirable on the precautionary principle. Alternative insecticides of the organophosphate, carbamate or pyrethroid groups available for house spraying are more biodegradable than DDT and are equally or more effective[11]. Switching from spraying DDT to use of pyrethroids is happening successfully in several malarious countries, eg. Vietnam, where both ITNs and pyrethroid spraying are used extensively. It is surprisingly hard to pin down the relevant costs of insecticides, but it seems that pyrethroids cost two to three times[11,22] as much as DDT per house sprayed, given that, in low-income countries, the insecticide represents a larger share of programme costs than spraymen's wages.

Bio-environmental control of malaria mosquitoes has been studied for almost a century, but there seems little prospect of success against the vector species in Africa and Southeast Asia, where breeding places are generally numerous small temporary water collections that are difficult to keep track of. Trials in India look more promising and cheap, but need adequate, replicated controlled trials to distinguish the effects of the interventions from the cyclical changes in malaria incidence that occur in India. Remedies such as mosquito-repellent plants and burning cow dung have their advocates, but these methods need to be proved to be effective, not just in reducing biting nuisance, but in suppressing malaria morbidity and mortality in communities in highly endemic areas.

Comparative trials in six countries have shown that when pyrethroid treatment of nets was provided free to whole communities (so that there was high population coverage), this method was as effective as house spraying with pyrethroids or with DDT[23–26]. In Pakistan, malathion spraying was less expensive than provision of pyrethroid-treated nets[26], but in Tanzania[23] it was calculated that house spraying with a pyrethroid would be more expensive than provision of bednets and annual re-treatment with the same pyrethroid (bulk purchased – not in the form of expensive individual sachets[1]). In China, where villagers already own nets, provision of deltamethrin treatment was reported to be even cheaper than DDT house spraying[27]. Treated nets are generally more acceptable to villagers than house spraying but, where there is an epidemic, as in the Madagascar highlands[7] a 'fire-brigade' reaction with house spraying should be more rapid and better targeted.

To avoid DDT elimination leading to reduced population coverage (the probable effects of which have been illustrated in Table 1), subsidies to cover any additional costs of replacement methods have been advocated by the United Nations Environmental

Box 1. Adverse Effects of DDT: Examining the Evidence[11–13]

DDT in food chains

- The long persistence of DDT residues in soil is often emphasized, but this is mainly based on data from temperate zones – in Sudan the half-life in soil was found to be only about three weeks[14].
- A worldwide survey[15] of DDT residues and its derivatives suggests that their distribution reflects past or present local agricultural usage and does not fit the distillation theory whereby residues are vaporized in the tropics and deposited in colder areas (which does fit better with the distribution of more volatile organochlorine insecticides).
- Illegal diversion of DDT intended for anti-malaria use to agriculture (which will occur so long as spraymen are paid low wages) might be the source of detectable residues in agricultural products intended for export, which may make them unacceptable to importers. Whether the very low residues detectable by modern analytical equipment are actually harmful to health is not known.
- Because DDT is sprayed on the inside surfaces of houses (especially mud walls), it has seemed unlikely that much would enter outdoor food chains, particularly as sprayed mud walls tend to be replastered. We think that the WWF's conclusion that 60–82% of DDT sprayed on a wall reaches the outside within six months (based only on K. Feltmate, Bachelor's Thesis, Trent University, Ontario, 1998) requires further investigation.

DDT and human health

- The health of spraymen in Brazil and India was similar to that of other men of their age[16].
- Earlier claims of DDT carcinogenicity were based on abnormally high DDE (a metabolite of DDT) residues in serum of patients dying of cancer. However, these were probably a consequence of the cancer causing body-wasting and hence mobilization of DDE from body fat deposits. A better design of such studies, to detect causes rather than effects of cancer, has been to store numerous serum samples, to wait until some of the subjects develop cancer and then to compare the DDE levels in their stored sera with those of matched controls. One such study found a just significant excess in breast cancer patients, but a meta-analysis of six such studies showed no significant effect[17].
- Abnormally high DDE was found in breast milk of women living in a South African area with anti-malaria spraying, compared with those in another area without spraying[18]. Whether this is harmful to the babies consuming the milk is not known. A negative correlation of time for which mothers lactate and DDE in their milk was reported in the USA[19]. However, much longer lactation times were reported from rural Belize, where there had been anti-malaria spraying with DDT for many years, than in urban populations in the USA or Belize where there has been no such use of DDT[20].
- DDT is claimed to be an oestrogen mimic[12] and possibly responsible for declining sperm counts in European men[21]. However, this decline has continued even though DDT usage is much less than it used to be, and it is very difficult to disentangle which of numerous pollutants might be responsible for the decline.

Programme and the Intergovernmental Forum on Chemical Safety. The World Bank provided $150 million to India to aid the replacement of DDT. A recent expert committee of the WHO emphasized that such subsidies should not be found by diversion from other health programmes. If affluent taxpayers consider that elimination of DDT is a matter of high priority, they, and not subsistence farmers, should be required to foot the bill.

Acknowledgements

We are grateful to Graham White, Donald Roberts and Wen Kilama for helpful comments, and to Shiv Lal, Manel Yapabandara, Anatole Kondrachine, Natalija Nikolaeva and Mayira Sojo-Milano for unpublished data.

References

1 Chavasse, D. *et al*. (1999) *Insecticide Treated Net Projects: a Handbook for Managers*, Malaria Consortium, London School of Hygiene and Tropical Medicine
2 Kouznetsov, R.L. (1977) Malaria control by application of indoor spraying of residual insecticides in tropical Africa and its impact on community health. *Trop. Doctor* 7, 81–93
3 Sharma, G.K. (1987) A critical review of the impact of insecticidal spraying under NMEP on the malaria situation in India. *J. Communic. Dis.* 19, 187–290
4 Litsios, S. (1996) *The Tomorrow of Malaria*, Pacific Press
5 Bruce Chwatt, L.J. and de Zulueta, J. (1980) *The Rise and Fall of Malaria in Europe*, Oxford University Press
6 Sharp, B.L. and Le Sueur, D. (1996) Malaria in South Africa: the past, the present and selected implications for the future. S. *Afr. Med. J.* 86, 83–89
7 Mouchet, J. (1997) La reconquête des Hautes Terres de Madagascar par le paludisme. *Bull. Soc. Path. Exot.* 90, 162–168
8 Gabaldòn, A. (1983) Malaria eradication in Venezuela: doctrine, practice and achievements after twenty years. *Am. J. Trop. Med. Hyg*. 32, 203–211
9 Roberts, D.R. *et al*. (1997) DDT, global strategies and a malaria control crisis in South America. *Emerg. Infect. Dis.* 3, 295–302
10 Melanby, K. (1992) *The DDT Story*, British Crop Protection Council
11 Curtis, C.F. (1994) Should DDT continue to be recommended for vector control? *Med. Vet. Ent.* 8, 107–112
12 World Wildlife Fund (1998) *Resolving the DDT Dilemma*, World Wildlife Fund
13 Smith, A.G. (1991) Chlorinated hydrocarbon insecticides. In *Handbook of Pesticide Toxicology* (Hayes, W.J. and Laws, E.R., eds), pp 731–915, Academic Press
14 El Zorgani, G.A. (1976) Persistence of organochlorine insecticides in the field in the Gezira soil under cotton. *Bull. Environ. Contam. Toxicol*. 15, 378–382
15 Simonich, S.L. and Hites, R.A. (1999) Global distribution of persistent organochlorine compounds. *Science* 269, 1851–1854
16 WHO (1973) Safe Use of Pesticides. *WHO Tech. Rep. Ser.* 513, WHO
17 Key, T. and Reeves, G. (1994) Organochlorines in the environment and breast cancer. *Br. Med. J.* 308, 1520–1521
18 Bouwman, H. *et al*. (1990) Levels of DDT in breast milk from Kwa-Zulu mothers after DDT application for malaria control. *Bull. WHO* 68, 761–768
19 Rogan, W.J. *et al*. (1987) Polychlorinated biphenyls and dichlorodiphenyl dichloroethene (DDE) in human milk: effects on growth, morbidity and duration of lactation. *Am. J. Public Health* 77, 1294–1297
20 Roberts, D.R. and Laughlin, L.L. (1999) Malaria control in South America – response to P.C. Matteson. *Emerg. Infect. Dis*. 5, 310–311
21 Sharpe, R.M. (1995) Another DDT connection. *Nature* 375, 538–539
22 WHO (1999) Control of Leishmaniases. *WHO Tech. Rep. Ser. 793*, WHO
23 Curtis, C.F (1999) Malaria control: bednets or spraying: background and trial in Tanzania. *Trans. R. Soc. Trop. Med. Hyg.* 93, 453–454
24 Mnzava, A.E.P. *et al*. (1999) Malaria control: bednets or spraying. *Trans. R. Soc. Trop. Med. Hyg*. 93, 455–456
25 Misra, S.P. *et al*. (1999) Spray versus treated nets using deltamethrin – a community randomized trial. *Trans. R. Soc. Trop. Med. Hyg*. 93, 456–457
26 Rowland, M. (1999) Malaria control in the Afghan refugee camps of western Pakistan. *Trans. R. Soc. Trop. Med. Hyg*. 93, 458–459
27 Pan Bo *et al*. (1999) Evaluation of cost-effect of bednets impregnated with deltamethrin for the control of *Anopheles anthropophagus* and malaria. *Chin. J. Parasite Dis. Contr*. 12, 59–62