

Viewpoint

DDT house spraying and re-emerging malaria

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Globally, numbers of malaria cases are increasing and the rate of increase is accelerating. This pattern is illustrated by multifold increases in malaria rates since 1979 in South America¹ accompanied by a rise in the proportions of populations at high to moderate risk of the disease. For example, populations at high to moderate risk more than doubled in Colombia and Peru from 1996 to 1997.^{2,3} Malaria is reappearing in urban areas and in countries that previously eradicated the disease (eg, urban areas of the Amazon Basin,⁴ South and North Korea,⁵ Armenia, Azerbaijan, and Tajikistan⁶). The frequency of imported malaria has also increased in industrialised countries (US and Europe⁶). Additionally, the increase in cases and the altered geographical distribution of malaria is underestimated because accurate information on global incidence is difficult to obtain and reports are generally fragmentary and irregular. Although many factors contribute to increasing malaria, the strongest correlation is with decreasing numbers of houses sprayed with dichlorodiphenyltrichloroethane (DDT).^{1,7,8} Recognition of this link and the start of negotiations by the United Nations Environment Programme (UNEP) for global elimination of DDT⁹ has fuelled an intense debate.¹⁰ The position of many scientists concerned about increasing malaria was described in an open letter¹⁰ that was subsequently signed by over 380 scientists, including three Nobel laureates in medicine, representing 57 countries. The letter supports continued use of DDT and residual spraying of houses for malaria control.

DDT in malaria eradication

Even in the earliest field studies, DDT showed spectacular repellent, irritant, and toxic actions that worked against malaria vector mosquitoes.¹⁰ When DDT was sprayed on house walls (2 g/m²) it exerted powerful control over indoor transmission of malaria.¹¹ As a consequence, house spraying produced excellent and rapid results in 1943 in the Mississippi Valley, USA, then in Italy, Venezuela, Guyana, India, and several other countries. House-spraying programmes functioned as national malaria-eradication services. The strategy encompassed vector control and case-treatment campaigns during the attack phase (3–5 years), followed by case treatment to eliminate the remaining parasites during consolidation and maintenance phases. As such, it was a multifaceted approach to disease control. Most countries adopted the

malaria-eradication strategy that was formulated and coordinated by WHO. Colonial Africa was left out of the “global” programme because of the lack of national structure and expertise. Even so, some African countries (South Africa, Zimbabwe, and Swaziland) developed successful national eradication programmes. Although malaria transmission could not be stopped by DDT in some areas such as the wet savannas of West Africa,¹² the overall effect of vertically structured programmes for applying DDT to house walls was an almost complete reduction or elimination of malaria.^{11,13,14} For example, malaria was eradicated from most of North America and Europe, and strong decreases in prevalence were seen in the Mediterranean Basin, the Middle East, the Far East, and even in southern Africa.

Resistance to DDT

Resistance of *Anopheles* spp mosquitoes to DDT is not a major barrier to the continued use of DDT for malaria control (ie, where DDT is still effective, it should be used). Resistance slowly appeared in the 1960s in response to intensive agricultural uses of DDT, especially in cotton production. The current distribution of DDT resistance among malaria vectors covers limited regions located in West Africa (*A gambiae*), southwest Asia (Iran, Pakistan, India, Sri Lanka; *A culicifacies*), Greece (*A sacharovi*), Egypt (*A pharoensis*), Central America (*A albimanus*), and a small area of Colombia in South America (*A darlingi*).^{15,16}

Environmental concerns

Claims of risks of DDT to human health and the environment have not been confirmed by replicated scientific inquiry. This is all the more remarkable given that DDT has been used for malaria control for almost 55 years. According to Curtis and Lines,¹⁷ toxicity of DDT in human beings and effects on the environment are questionable and require further investigation.

Since the early 1970s, DDT has been banned in industrialised countries and the interdiction was gradually extended to malarious countries. The bans occurred in response to continuous international and national pressures to eliminate DDT because of environmental concerns. Global trends of decreasing numbers of sprayed houses started with changing strategy from the vector-control approach to malaria control. Despite objections by notable malariologists¹⁸ (also Arnoldo Gabaldon¹⁹), the move away from spraying houses was progressively strengthened by WHO’s malaria control strategies of 1969, 1979, and 1992. These strategies were adopted even though published WHO documents and committee reports have consistently and accurately characterised DDT-sprayed houses as the most cost effective and safe approach to malaria control.^{12,20–22} Changing the emphasis on house spraying was further strengthened by a WHO plan, first introduced by the Director General of WHO in 1979,²³ to

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decentralise malaria-control programmes. This plan was adopted in World Health Assembly Resolution 38.24 in 1985.²⁴ From then on, for countries to qualify for foreign or international assistance, they were expected to comply with WHO guidance on house spraying and to incorporate malaria control programmes into primary health-care systems. Additionally, assistance from industrialised countries was often specifically contingent on not using DDT.

Other mechanisms also have been used by environmental advocates to stop use of DDT for malaria control. A recent example is the agreement of the North American Commission for Environmental Cooperation (CEC) that forced Mexico to stop producing and using DDT for malaria control.²⁵ This agreement also eliminated a rare source of DDT for malaria control in other countries in South America. Claims by environmental advocates²⁶ that Mexico is “now” a test-bed for a new model of “malaria control without DDT” ignores the simple fact that Mexico is a developed country (ie, it is one of the richest of malaria-endemic countries). Consequently, years from now, the outcome for Mexico will show how a scientifically and economically rich country can or cannot control malaria without DDT. Even if Mexico is successful in maintaining control of malaria without use of DDT,²⁷ this success will not be relevant for countries with serious malaria problems and the methods used may not be useful or affordable in more needy and scientifically impoverished countries.

On a landscape scale, a sprayed house will only have a very small amount of DDT enclosed in the walls. Nevertheless, environmentalists are still seeking a global ban^{26,28,29} arguing that if DDT is produced for use in improving public health, it will also be used for agriculture and lead to global pollution of the environment.^{26,27} This instance of environmental advocacy seems to have won approval of powerful pesticide companies because it allows them to sell their more expensive insecticides. The replacement of DDT by organophosphate, carbamate, or pyrethroid insecticides is commonly proposed even though price, efficacy, duration of effectiveness, and side-effects (eg, unpleasant smell), are major barriers to their use in poor countries. High costs and downward trends in foreign assistance discourage many countries that cannot afford the switch to DDT alternatives. Although arguments can be mounted on both sides of the issues of cost-effectiveness, duration of activity, and safety of alternative insecticides, there should be no confusion about what happens to public health when use of DDT is banned.

Consequences of the ban

When a malaria-endemic country stops using DDT, there is a cessation or great reduction in numbers of houses sprayed with insecticides, and this is accompanied by rapid growth of malaria burden within the country.^{1,12,17} DDT house spraying was stopped in Sri Lanka in 1961, and this was followed by a major malaria epidemic. Since then, numerous epidemics have occurred in many countries, after suspension of DDT house treatments, such as Swaziland (1984) and Madagascar (1986–88), where malaria killed more than 100 000 people. In both cases, the authorities restarted DDT house spraying and stopped the catastrophic epidemics.⁸ In Madagascar, malaria incidence declined more than 90% after just two annual spray cycles. Today, few countries still use DDT and most have no way to even buy this insecticide. Without DDT, malaria rates

are returning to those seen in the 1940s, affecting additional millions of infants, children, and adults.

WHO's Global Malaria Control Strategy (GMCS)³⁰ of 1992 and the current Roll Back Malaria³¹ initiative emphasise treatment of cases and protection of people with impregnated bednets. The failure to include DDT house spraying results from antagonism between the horizontal medical structures and the vertical ones that are needed to restart house-spraying programmes. In other words, more is involved than some undefined opposition to use of DDT. Additionally, some sponsors make the banning of DDT a condition of their support and also require that malaria control be done within a primary health-care system. Because of these multiple factors, the GMCS or Roll Back Malaria initiative, as formulated, will not stop progression of the ongoing global resurgence of malaria.

The future

There is no ideal solution to the problems of malaria control, and DDT house spraying has its limitations. However, DDT remains a remarkably effective tool that should still be used. There is a continuing need for operational research to improve the cost-effectiveness of this approach. It is an astonishing fact that WHO guidance for spraying houses is the same today as it was in the eradication era (2 g of DDT/m² of wall surface every 6 months). New and improved approaches to malaria control should have evolved from the wreckage of the eradication programme. For example, a yearly cycle instead of the standard 6-month spray cycle might have produced adequate amounts of control in many environments^{32,33} (eg, Madagascar^{8,12}). If effective, this change alone could have reduced amount of insecticide used in some control programmes by 50%. Partial spraying of houses might have produced control comparable to complete wall coverage.³⁴ Improved methods for prioritising spray operations by risk factors could have further increased the cost-effectiveness of limited malaria-control resources.^{35–37} Indeed, even today, small investments along these lines of applied research could produce large cost savings and reductions in insecticide usage.

We recommend that the global response to burgeoning malaria rates should allow for DDT residual house spraying where it is known to be effective and necessary. For this to happen, it might be necessary to create new or rehabilitate the old organisational structures.³⁸ Regulations and policies of industrialised countries and international agencies that block financial assistance to countries that use DDT for malaria control should be eliminated. One organisation should be created with the ability to manufacture and distribute DDT to public-health organisations in countries that need it. This centralised system will help guarantee that DDT is used for public-health purposes only. In addition, the necessary quantity of DDT for vector control will be so low that even if diverted, it will not be enough to pollute the environment.

The views expressed are those of the investigators and do not reflect the official policy or position of the USUHS, the Department of Defense, or the US Government.

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