

Cod: 2.4001

ENVIRONMENTAL AND HUMAN HEALTH CONSEQUENCES OF DDT USED IN SOUTH AFRICA FOR MALARIA CONTROL

H. Bouwman¹, H. Kylin², R. Bornman³

¹North-West University, Research Unit for Environmental Sciences and Management, Potchefstroom, South Africa

²North-West University, Research Unit for Environmental Sciences and Management, Potchefstroom, South Africa & Department of Thematic Studies - Environmental Change, Linköping University, Linköping, Sweden

³University of Pretoria Centre for Sustainable Malaria Control, and School of Health Systems and Public Health, University of Pretoria, Pretoria, South Africa

Introduction

DDT has been used for malaria control since the late 1940s in South Africa. Indoor residual spray (IRS) is the main method of application. Up to 2 g/m² is applied on indoor wall surfaces, rafters, and other places where mosquitoes tend to rest during daytime. It is here where the IRS-applied DDT encounters the resting female *Anopheles* mosquitoes that have taken their first human blood meal. If this person was previously infected with malaria, the malaria parasite now infects the mosquito, develops through a sexual stage, and becomes infective during the period when the female mosquito is digesting the blood meal for egg formation. Female *Anopheles* mosquitoes need a second blood meal to complete egg formation. While conducting the second blood meal on an uninfected person, malaria parasites are transferred to the human host via the anti-coagulating saliva injected. DDT (or any other pesticide applied to the walls for that purpose) either kills the mosquito between the meals, or forces the mosquito outdoors. In this way, the transmission is interrupted. This method, developed by Botha de Meillon developed in the 1930s has been a mainstay of malaria prevention in many parts of the world, and has saved millions of lives. DDT is long-lasting and protects against transmission throughout a season, but needs yearly re-application to remain effective.

Problem statement

The deliberate application of a pesticide, sufficiently long-lasting to enable the interruption of malaria transmission, inside human habitation in very close human proximity is required for effective protection. This same intimate proximity however, also brings the human inhabitants (just like the mosquito) in contact with the same insecticide that is protecting them from malaria. It is therefore inevitable that residues of these insecticides, particularly DDT, will be found in the bodies of the human residents. The obligation of many humans to endure such close proximity to a toxic substance for large parts of their lives is a compromise that few of us would otherwise willingly entertain for our children or ourselves.

Advancing the debate

The debate on DDT, starting with Rachel Carson, has been vigorous and often acrimonious. The conflict arises out of the continued need to use DDT in parts of Africa as a very effective interrupter of malaria transmission, opposed by the impacts that have led to its otherwise complete banning in the world, notably through national legislation and the Stockholm Convention on Persistent Organic Pollutants. The lethal doses of DDT required to kill warm-blooded animals is much higher than for insects that are more susceptible. However, the sub-lethal effects that have by now been ascribed to DDT, notably its endocrine disruptive activities, has focused the spotlight on issues not originally considered when assessing the inherent dangers of placing DDT in close and near-continuous proximity to humans, as well as the effects of DDT leakage to the environment. Subsequent human health assessments were ambiguous about human health impacts of DDT as applied to control vector-borne diseases, although acknowledging high exposures. Much of the studies that have been used to derive such assessments do not reflect the DDT exposure scenarios encountered for malaria control.

Now, however, more studies have come to the fore from which to draw inferences and deductions, and we will do so here. We should consider whether DDT's human health and environmental costs necessitates moving away from DDT as quickly and sustainably as possible without compromising the gains achieved through decades of use, and the ability for malaria's eventual eradication. We will show that much new information supports the urgency of moving away.

New developments

The last 15 or so years have seen an encouraging increase in published ecotoxicological science from developing countries, including countries that battle malaria. Much of this has been due to multilateral capacity development through direct support, and bilateral partnerships, especially with European countries, but also the USA, Japan, and China. Inevitably, DDT has been one of the centrepieces of such research as it was in the preceding decades in developed countries. However, now, new knowledge, insights, and techniques can be brought to bear, placing some of the projects on an advanced footing to look at possible impacts of DDT, especially at a molecular level. Also, despite the decades of research on DDT, very little DDT-related research has actually been carried out under malaria control situations. With a growing analytical and ecotoxicological capacity in developing countries, new data on wildlife exposure shows that extrapolation from situations from elsewhere may be indicative but not ultimately predictive of the findings under malaria control conditions. We will list and discuss such new findings, specifically compiled from areas where DDT is used for malaria control.

Endpoints of human health research now include:

- Urogenital birth defects
- Ample evidence of very high exposures of babies to DDT via breast milk
- High DDT concentrations in blood
- Sperm count and motility
- Sperm morphology
- Sperm chromatin defects
- Ejaculate volume
- pH
- FSH and LH
- Testosterone
- Estradiol
- Thyroid hormones
- Retinol binding protein
- Anogenital distance
- Antimüllerian factor
- Hypospadias
- Cryptorchidism
- Urogenital birth defects

In addition, we understand the dynamics and human contact patterns with DDT under IRS and homestead conditions much better:

- DDT in indoor soil, dust, water, and air.
- DDT in chickens, eggs, milk, and vegetables
- Outdoor movement

Endpoints of environmental impacts now include:

- Very high concentrations of DDT in fish
- Very high concentrations of DDT in both aquatic and terrestrial birds
- Signs of endocrine disruption in fish associated with DDT
- Biomarker deviations associated with DDT
- Signs of developmental impairment in frogs associated with DDT
- Eggshell thinning in terrestrial birds associated with DDT
- Apparent absence of breeding water birds in DDT-sprayed areas

Included in the above are endpoints that do not show any association with or sensitivity to DDT, and these will be mentioned. However, the litany of indications that DDT is causing harm to human health and environment is impossible to ignore.

Advancing the debate

We have listed many indications and warnings of the dangers associated with DDT as used in malaria control in South Africa. We believe that much of this is also true for other countries and regions with similar IRS practices. Clearly, more than enough evidence has been garnered, and even more being collected. Now what to do with all this?

The willingness to listen to the early warning signs is coupled with vested interests often contrasted with the need to advance, based on new knowledge and concerns. Science is continuously discovering more ways and means to investigate possible harm at deeper levels from ecology through to molecular levels of organisation. We have shown that we need to move away from DDT. If there is a continued need for DDT, then this should be adequately weighed against the consequences of its use, even when its advantages (saving human lives outright) carries human health and environmental burdens far into the future. Ethically, we should also be concerned with spreading the knowledge to communities. After all, Jean Rostand (a French biologist and philosopher) famously said “The obligation to endure gives us the right to know.”

One chapter of *Silent Spring* is entitled “The other road”. We believe that there are other roads that can be followed, even if these are difficult. As Rachel Carson said more than 50 years ago “The choice, after all, is ours to make.”